PART III

NAS ARCHITECTURE DESCRIPTION

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14 PART III NAS ARCHITECTURE DESCRIPTION OVERVIEW

Sections 15 through 32 discuss the NAS functional areas. Figure 14-1 illustrates the sequence of these functional areas by section number. Each section covers the following topics for each functional area:

- Overview
- Evolution
- Summary of Capabilities
- Human Factors
- Transition
- Costs
- Watch Items.

Figure 14-2 depicts the evolutionary steps of each major functional area by calendar year and shows the relationship of the steps to overall phases of NAS modernization. No effort was made to synchronize the dates of the steps across the domains. The steps occur when appropriate for each domain, given the program and implementation schedules involved.

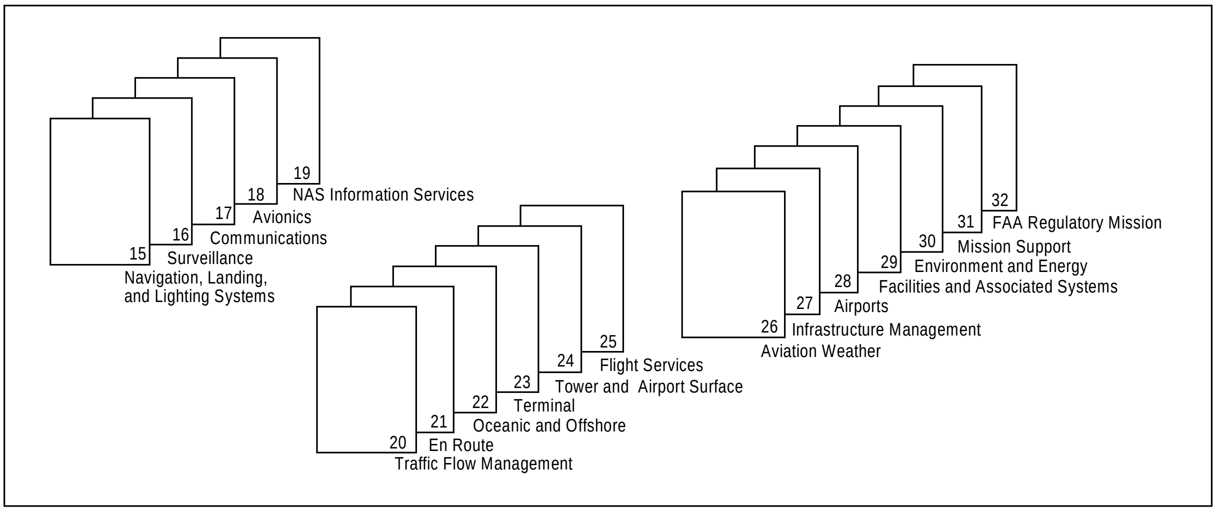

Figure 14-1. Roadmap of Functional Areas

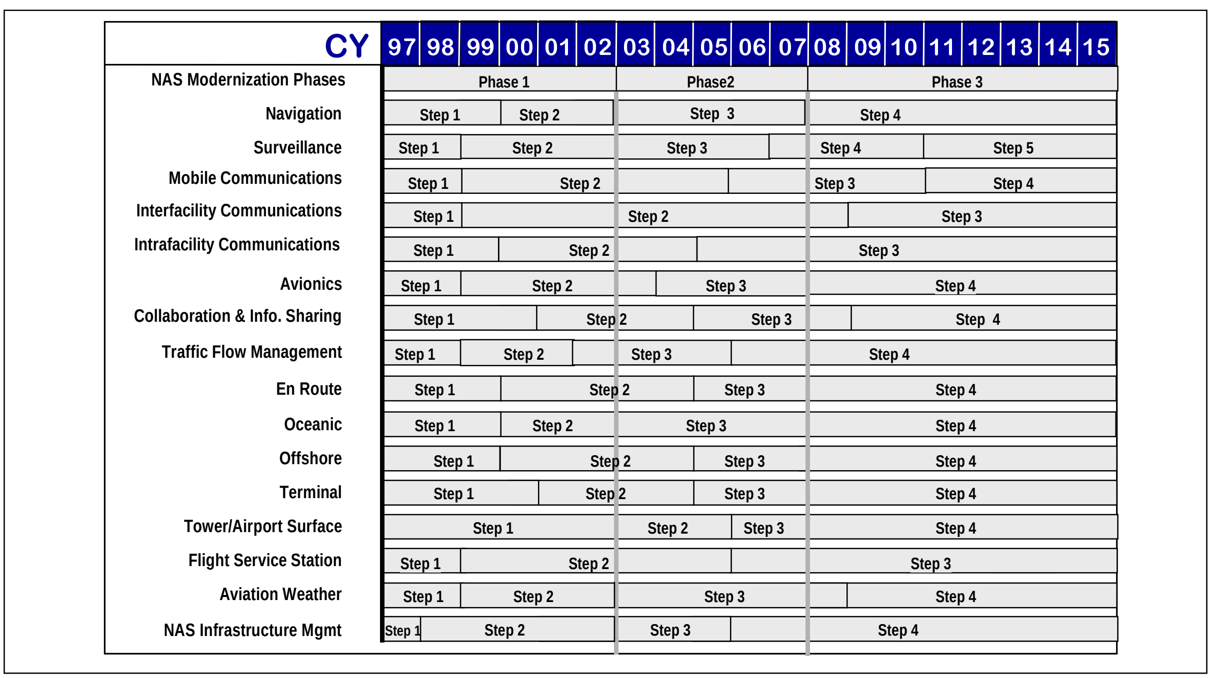

Figure 14-2. Functional Area Architectural Steps

15 NAVIGATION, LANDING, AND LIGHTING SYSTEMS

The FAA, the Department of Defense (DOD), and nonfederal agencies operate more than 4,300 ground-based electronic navigational aides (Navaids[1]) that broadcast navigation signals within a limited area. This network of Navaids enables users with suitable avionics to navigate en route and safely fly nonprecision (course guidance only) and precision approaches (course and glide path guidance) in most meteorological conditions.

The FAA also provides a variety of approach lighting systems that enhance pilot transition from instrument reference to visual reference for landing. Operational requirements, including the specific approach to be flown, dictate the types and configuration of the approach lighting system for a particular runway. Approach lighting systems enable Category (CAT) I precision instrument approaches to be flown to one-quarter-mile lower visibility minimums.

The navigation and landing system will evolve from ground-based Navaids to a satellite-based system that will consist of the Global Positioning System (GPS) augmented by the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS). The satellite-based system will meet the demand for additional navigation and landing capabilities and improve safety while avoiding the cost of replacing, expanding, and maintaining many of today's ground-based Navaids.

The satellite-based navigation system will provide the basis for NAS-wide direct routing, provide guidance signals for precision approaches to most runway ends in the NAS, and reduce the variety of navigation avionics required aboard aircraft. Operational efficiency and safety will be improved by adding more than 4,200 precision approaches (and an additional 4,200 nonprecision approaches) at many airports lacking such capabilities today (see Section 28, Airports).

In order to take advantage of the opportunity the new capabilities offer to significantly increase capacity and to meet FAA forecasts for increased traffic, severely congested airports may require additional airport development (in terms of both clearance categories and pavement). Aviation system users and airports at low-capacity locations who want to take advantage of new opportunities may incur additional airport development costs.

DOD plans to replace the current GPS satellite constellation beginning in 2005. The new satellites will feature an additional frequency (i.e., a second frequency) to improve performance for civil use.

After sufficient time to allow for installation of satellite-based avionics and sufficient experience with WAAS and LAAS operations, a phase-down of ground-based navigation systems will begin. The phase-down is expected to begin in 2005. The exact timetable and extent of Navaid decommissioning will depend on the performance of the satellite-based systems, international agreements, and user acceptance.

Congress has directed a slowdown in WAAS until technical and programmatic uncertainties are resolved. Initial operating capability (IOC) for WAAS is expected to begin in 2000. IOC is expected to provide en route navigation and nonprecision and precision approach capability with some operational restrictions. Incremental improvements after IOC will enable pilots to use GPS/WAAS avionics for all phases of flight during instrument meteorological conditions.

There may be a need for a limited number of additional instrument landing systems (ILSs) to support new runways at capacity-constrained airports. These ILSs would be installed on an as-needed basis during the transition. Because GPS/WAAS is expected to provide service equivalent to a CAT I ILS, emphasis would be in supporting CAT II and III[2] requirements.

During phase-down, the reduced network of ground-based facilities (very high frequency

1. A Navaid is any visual or electronic device, airborne or on the surface, that provides point-to-point guidance information or position data to aircraft in flight, page 299, 1995 Airman's Information Manual/Federal Aviation Regulations (AIM/FAR).
2. Lowest authorized ILS minima are: CAT I, 200-foot decision height and 1,800 to 2,400-foot runway visual range (RVR); CAT II, 100-foot decision height and 1,200-foot RVR; CAT IIIa, no decision height and 700-foot RVR; CAT IIIb, no decision height and 300-foot RVR (Reference: FAA Order 8400.10 U.S. Standard for Terminal Instrument Procedures).

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(VHF) omnidirectional range/distance measuring equipment (VOR/DME), nondirectional beacons (NDBs), tactical air navigation (TACAN), or ILSs)) will enable users who are not equipped with satellite-based avionics to continue to fly in the NAS. In some areas, these aircraft will need to follow more circuitous routes than aircraft with satellite-based avionics. In the event of an unexpected localized loss of satellite-based services, aircraft equipped exclusively with satellite-based avionics in airspace with radar services will be vectored to visual conditions, to areas where Navaid reception provides backup, or to regions unaffected by the loss of the satellite navigation (SAT NAV) signal.[3]

Studies are underway to: (1) determine how many ground-based facilities should remain in service to provide a temporary/permanent redundant navigational capability, and (2) determine whether GPS/WAAS can be the only navigation capability carried aboard an aircraft and provided by FAA. The NAS Architecture will be revised in accordance with the study results.

15.1 Navigation and Landing Architecture Evolution

The following four steps present the evolution from ground-based to satellite-based Navaids:

- Step 1: Navigation and Landing Architecture (Current–1999)
- Step 2: Implementation of WAAS (2000–2002)
- Step 3: Completion of WAAS; Implementation of LAAS; Start Phase-Down of Ground-Based Navaids (2003–2007)
- Step 4: Completion of Phase-Down of Ground-Based Navaids (2008–2015).

15.1.1 Navigation and Landing Architecture Evolution—Step 1 (Current–1999)

Figure 15-1 illustrates the current navigation architecture. The VOR/DME network provides users with a primary means of navigation for en route flight and nonprecision approaches. The network consists of more than 1,000 VOR, VOR/DME, or VORTAC (VOR co-located with TACAN) facilities. The DOD operates an additional 30 such facilities at terminal locations.

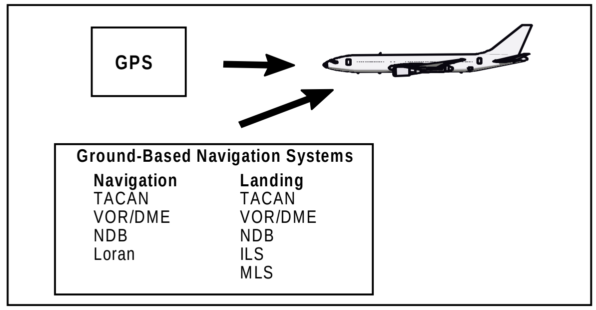

Figure 15-1. Current Navigation Architecture

To supplement the VOR/DME network, the FAA operates more than 700 NDBs, and the DOD about 200 NDBs. NDBs are used as compass locators in conjunction with some ILSs and for nonprecision approaches at low-traffic airports without convenient VOR approaches. NDBs are also used for en route operations in some remote areas and for transitioning from oceanic to domestic en route airspace.

The FAA operates more than 600 TACAN systems to provide air navigation for most military aircraft. DOD also operates more than 150 TACANs. The U.S. Coast Guard operates the Loran-C system, which can be used for en route navigation in the NAS, provided another system (VOR/DME, NDB, or TACAN) is carried onboard. Current Loran-C avionics do not support instrument approach operations.

The FAA and DOD operate two types of precision approach Navaids: ILS and a limited number of microwave landing systems (MLS). The FAA operates about 1,000 ILSs and 26 MLSs. DOD operates 180 ILSs and precision approach radars.

DOD operates the GPS satellite constellation. GPS provides worldwide, all-weather, 3-dimensional position, velocity, and time data to a variety of civilian and military users. GPS is approved for en route navigation and nonprecision approaches, provided that another system (VOR/DME, NDB, or TACAN) is carried onboard. Certain GPS receivers are approved for navigation in oceanic and remote airspace; no other navigation systems are required onboard.

3. While some surveillance systems will evolve to make use of the GPS signals, surveillance radars will not be dependent on GPS (see Section 16, Surveillance).

The FAA operates and maintains approximately 1,000 approach lighting systems. They consist of a configuration of lights starting at the landing threshold and extending into the approach area. Some systems include sequenced flashing lights that appear to the pilot as a ball of light traveling toward the runway at high speed.

A variety of approach lighting system configurations exist. The most common are the medium-intensity approach lighting systems with runway alignment indicator lights (MALSR) to support CAT I precision approaches and the high-intensity approach lighting system with sequenced flashing lights (ALSF-2) to support CAT II and CAT III precision approaches.

The FAA also operates and maintains approximately 1,700 visual glide slope indicators. These consist of 1,350 visual approach slope indicators (VASIs) and 350 precision approach path indicators (PAPIs). Visual glide slope indicators provide visual reference to pilots as they approach the runway for landing. Currently, the FAA is replacing the VASIs with PAPIs because PAPIs conform to International Civil Aviation Organization (ICAO) international standards while VASIs do not.

Depending on their operational needs and financial constraints, users choose to equip their aircraft with a variety of avionics for navigating in the NAS. These include:

- *GPS:* Provides navigation in oceanic and remote airspace. It can be used for en route navigation and nonprecision approaches in domestic airspace, provided another system (VOR/DME, NDB, or TACAN) is carried onboard.
- *VOR/DME:* Provides navigation guidance for en route navigation and nonprecision approaches (TACAN for DOD).
- *ILS:* Provides navigation guidance for CAT I/II/III precision approaches.
- *Automatic Direction Finder (ADF):* Provides direction to an NDB ground transmitter. One use is for a nonprecision instrument approach, based on tracking to or from the beacon, without an electronic glideslope.
- *Loran-C:* Can be used for en route navigation, provided another system (VOR/DME, NDB, or TACAN) is carried onboard. Current Loran-C avionics do not support instrument approach operations.
- *Inertial Systems:* Are self-contained systems used in many military and transport aircraft for oceanic and domestic en route navigation.
- *MLS:* Provides a limited number of CAT I precision approaches and some nonprecision instrument approach operations.

Nonfederal organizations (i.e., airport authorities, states, airline operators, etc.) fund and operate approximately 1,500 Navaids at locations that do not qualify for federal funding due to insufficient traffic. These organizations maintain and operate the Navaids, and the FAA inspects and verifies their safe operation under the nonfederal program. The nonfederal Navaids include approximately: 200 ILSs, 1,000 NDBs, 60 VORs, 100 DMEs, 10 MLSs, and 50 to 100 lighting aids of various types.

15.1.2 Navigation and Landing Architecture Evolution (Implementation of WAAS)—Step 2 (2000–2002)

The implementation of satellite navigation will help the NAS to meet increasing aviation traffic and will allow a reduction in the number of ground-based Navaids. The GPS signal must be augmented to ensure accuracy, integrity, continuity, and availability (see Figure 15-2). WAAS will augment the GPS signal for en route and terminal navigation and instrument approaches. GPS, augmented by WAAS, will provide instrument approaches to CAT I minima at most runway ends in the NAS (where obstacle clearance, runway,

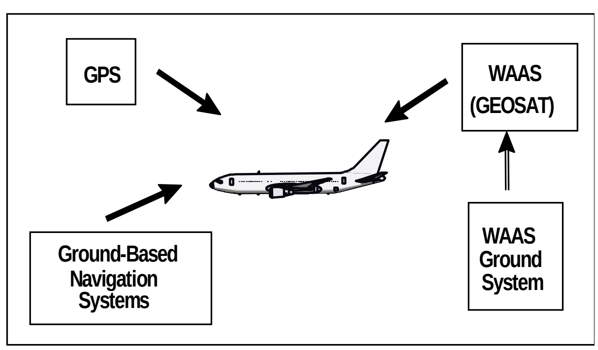

Figure 15-2. GPS Augmented by WAAS

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lighting, and signage requirements are met). Because WAAS can provide precision approaches to new runways, to CAT I minima if required, the need for new ILS CAT I approach equipment will be eliminated. In addition to added instrument approaches, users will benefit from increased area navigation and more direct routing.

WAAS consists of master stations and precisely surveyed reference stations interconnected by a terrestrial communications infrastructure. Communications from the ground master stations are broadcast to aircraft via WAAS geostationary satellites (see Figure 15-3).

To improve GPS accuracy, WAAS geostationary satellites (GEOSATs) will broadcast differential corrections for ionospheric delay, satellite position, and satellite clock errors. The reference stations monitor the GPS and WAAS signals to ensure system integrity and report any anomalies to the master station. GEOSATs broadcast status to the aircraft avionics. Availability is improved because WAAS geostationary satellites appear to the avionics as additional GPS satellites.

WAAS will be implemented in phases, with operational capability improving at each phase. The initial phase, which consists of 25 reference stations, 2 master stations, and GEOSAT uplink stations, has been installed. It is in the process of being networked and tested to provide an initial operating capability (IOC) for flight operations in 2000. The IOC will provide signals for domestic en route navigation and nonprecision and precision instrument approaches with operational restrictions within a limited WAAS coverage area.

During this phase, WAAS-equipped aircraft will be able to fly instrument flight rules (IFR) without having other navigation avionics aboard (e.g., VOR/DME or NDB). However, procedural or operational restrictions may affect the availability of GPS/WAAS approaches in some areas of the country. Flights in these areas will need to rely on existing procedures and VOR/DME or NDB.

The initial phase of WAAS will provide CAT I precision approach capability within a limited coverage area. However, the precision approach minima initially authorized may be somewhat higher than current CAT I ILS minima while both the FAA and aircraft operators gain experience. Procedural or operational restrictions may affect approach availability.

Decisions on approach minima will need to be made at some locations where ½-mile visibility is not necessary, thus avoiding the high cost of instrument approach lighting systems. During this initial phase, pilots who need to plan for an IFR alternate airport may need to rely on visual approach procedures or on Navaids, such as ILS, VOR/DME, or NDB, similar to operations today. The initial WAAS precision approach coverage area will be limited, depending on the location of WAAS reference stations and the coverage of WAAS satellites. The coverage volume will gradually increase as data are collected to substantiate GPS/WAAS ionospheric performance.

An interim phase will provide additional master and reference stations to improve WAAS coverage, performance, and real-time availability. Automated notice to airmen (NOTAM) service with predictive capabilities will become available.

Instrument approach procedures based on GPS/WAAS will be published by WAAS IOC. Subsequently, 500 procedures will be published each year until requirements are met. In addition, 500 GPS nonprecision approach procedures will be developed annually.

15.1.3 Navigation and Landing Architecture Evolution (Completion of WAAS, Implementation of LAAS, Start Phase-Down of Ground-Based Navaids)—Step 3 (2003–2007)

In its final phase, WAAS will achieve full operating capability (FOC) by the addition of ground monitoring and control stations and geosatellites. Hardware installed earlier in the program will be upgraded. WAAS will then provide performance equivalent to ILS CAT I with a level of service that is sufficient to replace existing VOR/DME and NDB facilities and most CAT I ILS facilities. Also at FOC, the interim procedural and operational restrictions imposed at IOC will be removed.

To provide additional precision approaches, LAAS will be installed to augment GPS in this step. LAAS will augment GPS at a planned 112 airports in the NAS to provide CAT II/III precision approaches (see Figure 15-4).

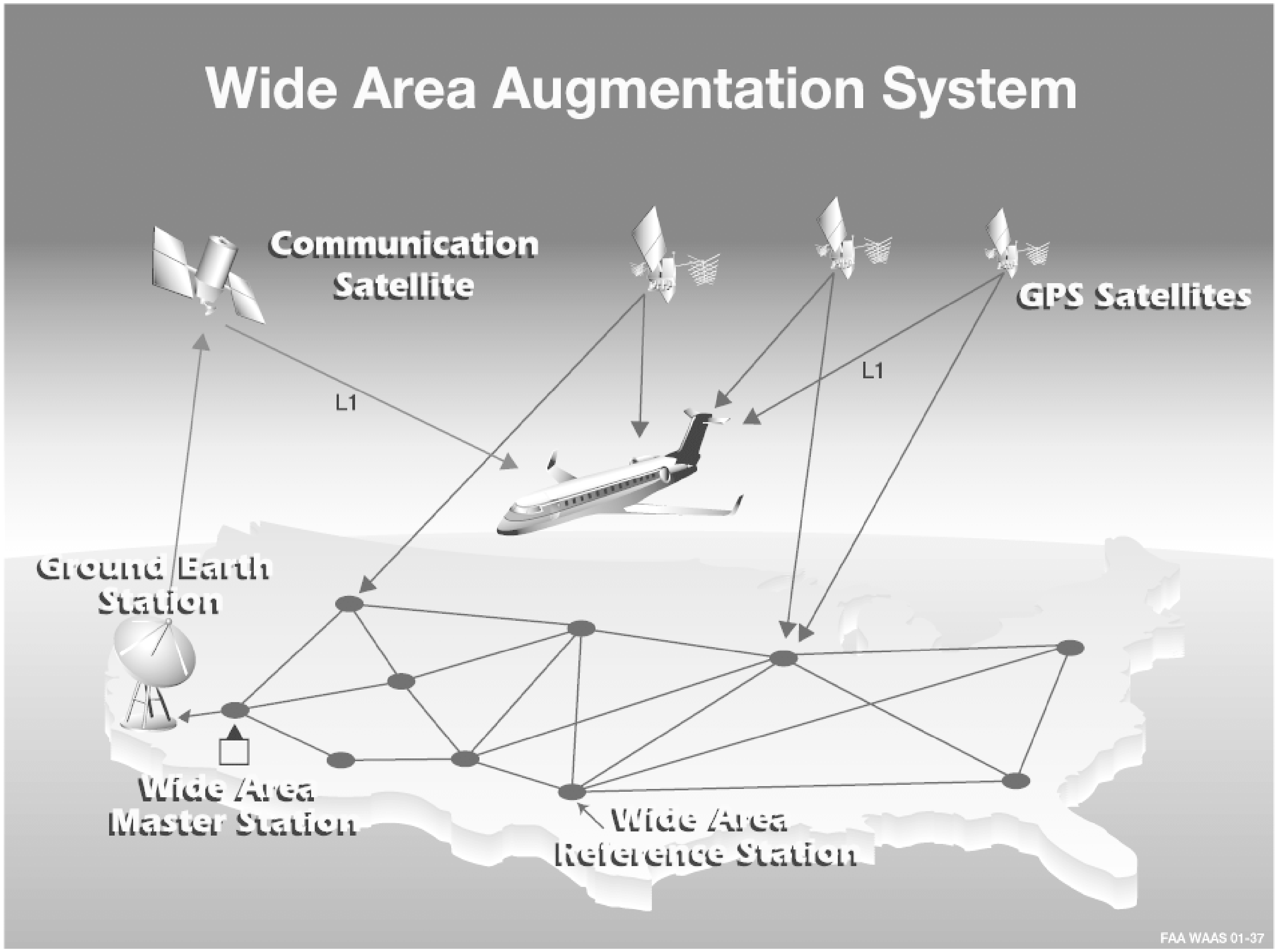

Figure 15-3. Wide Area Augmentation System

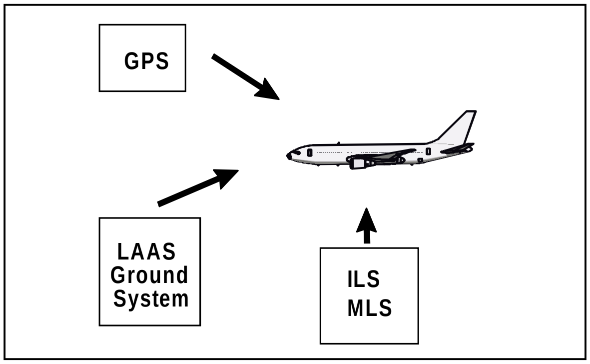

Figure 15-4. GPS Augmented by LAAS

LAAS will also provide CAT I precision approaches at a planned 31 airports that are either outside of WAAS coverage (17) or have high activity that requires a higher availability than WAAS can support (14). LAAS capability does not require WAAS, and its implementation schedule is independent of the WAAS program. The LAAS architecture is shown in Figure 15-5.

Suitable approach lighting systems will be installed to support additional precision instrument approach procedures enabled by LAAS.

A LAAS installation is anticipated to consist of a precisely surveyed ground station with multiple GPS receivers, a VHF link, and one or more pseudolites[4] to increase availability. The LAAS ground station will calculate differential accuracy corrections based on the station's location and on measurements taken from each GPS satellite. It will then broadcast the corrections on VHF radionavigation frequencies, together with an integrity message, to aircraft within a radius of 20 to 30 nmi from the airport. LAAS is expected to be significantly more affordable to install, operate, and maintain than ILS. One LAAS will allow CAT II/III precision approaches at all runway ends at an airport, topology and lighting equipment permitting. This is a savings compared to ILS technology, which requires each runway end to have an ILS.

LAAS is expected to support ground operations such as runway incursion avoidance and airport surface navigation and surveillance. For additional information about how LAAS will be used in the NAS, refer to Section 16, Surveillance; Section 18, Avionics; Section 23, Terminal; and Section 24, Tower and Airport Surface.

The FAA's plans for the transition to SAT NAV technology and for the phaseout of ground-based Navaids will be periodically reevaluated. An FAA-funded risk assessment study is being conducted to determine whether satellite navigation technology can serve as an only means of radionavigation in the NAS. Assessment results are expected in early 1999. If it is determined that GPS/WAAS/LAAS cannot satisfy the performance requirements to be the only navigation system installed in an aircraft or provided by the FAA, then it may be necessary to maintain a reduced network of ground-based Navaids beyond 2010 to support satellite navigation.

As soon as circumstances permit, the FAA plans to begin reducing the number of ground-based Navaids in a two-step phase-down. Criteria for identifying the Navaids to be shut down will be published well ahead of the first step.

Prior to starting the first step of phase-down, the FAA, in conjunction with users, expects to determine whether the phase-down schedule should be adjusted. Preliminary analysis indicates that approximately 350 VORs and 300 ILSs would be shut down in the first step, leaving sufficient ground-based Navaids to enable users who are not equipped with satellite-based avionics to continue to fly in the NAS.

15.1.4 Navigation and Landing Architecture Evolution (Completion of the Phase-Down of Ground-Based Navaids)—Step 4 (2008–2015)

Completion of the first step of the ground Navaid phase-down is expected in 2008. A second step, slated for 2009 to 2010, would shut down approximately 100 VORs, 250 ILSs, and 470 NDBs.

The remaining Navaids (approximately 600 VOR/DMEs, 500 ILSs, and 280 NDBs) would be sufficient to support en route navigation and instrument operations at the busier airports in the NAS (about 2,400) should there be a disruption in GPS/WAAS service.

4. A pseudolite is a ground-based transmitter of GPS-like signals that are used for ranging. The number and placement of pseudolites will depend on the topology of each site.

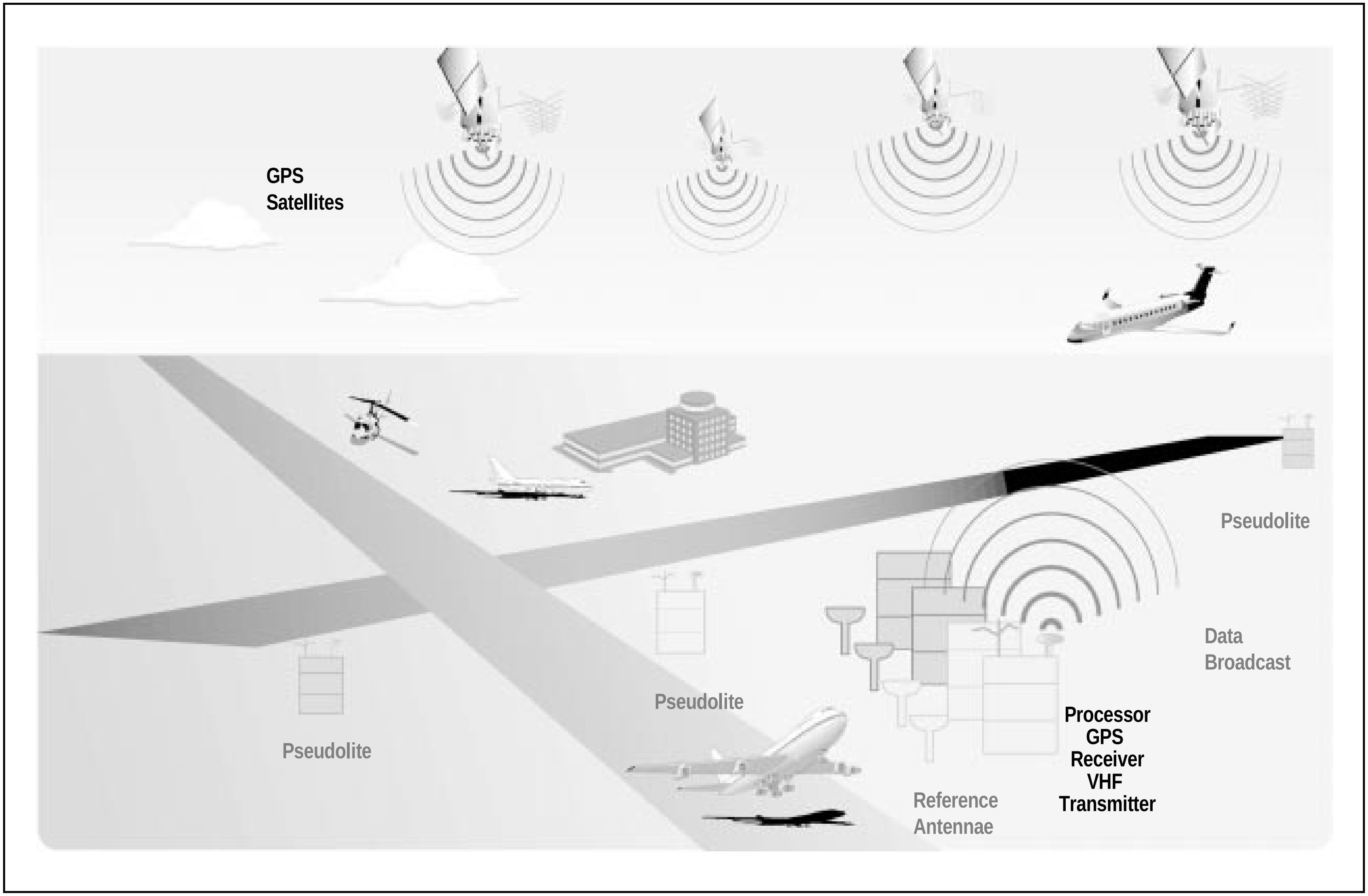

Figure 15-5. LAAS Architecture Overview

Because precision landing services will eventually depend primarily on the use of GPS signals augmented by WAAS and LAAS differential correction signals, it is clear that these systems need to be protected from harmful interference. The FAA[5] is currently working with DOD to develop safety and system security countermeasures for satellite-based navigation and landing systems to prevent or mitigate interference such as jamming. Integrity of the satellite-based system will be assured prior to phasing out ground-based Navaids. New GPS satellites with a second civil frequency capability will be launched during this period to replace all the current GPS satellites. The addition of the second civil frequency will mitigate the effects of unintentional jamming and could also provide increased accuracy by means of the direct measurement of ionospheric delay by aircraft dual-frequency avionics.

Ground-based systems are expensive to procure, install, and maintain. Current NAS planning includes sufficient funding to maintain the Navaid infrastructure in accordance with near-term aviation growth and with the navigation and landing architecture described herein (i.e., with a Navaid phase-down).

However, if users do not convert to GPS-based avionics, and if plans to phase out ground-based Navaids are not realized, then Navaids reaching the end of their service life will need to be replaced.

Currently, it costs the FAA $170M annually to operate the ground-based system. Replacing the ground-based systems would require an estimated $2.61B investment.[6] Additionally, if users do not convert to GPS-based avionics, more ground-based Navaids will be needed over time to support aviation growth. For example, more than 200 airport authorities have requested, and are eligible for, new ILS installations.[7]

Substantial investment would be required to install or replace Navaids designed to support a 1950's operational concept. Such an investment would not improve NAS operations, whereas WAAS and LAAS support direct routes and enable more flexible use of airspace.

After satellite-based systems are deployed and certified, and before other Navaid systems can be phased out[8] (see Figure 15-6), the following three essential prerequisites must be met:

System Performance. New technology must meet service requirements. This will be determined through analyses, flight tests, and operational experience.

Operational/Economic Benefits. There must be sufficient operational and economic incentive before users will invest in satellite-compatible avionics. Economic benefits include using a WAAS or a WAAS/LAAS receiver in lieu of multiple avionics, fuel savings from user-preferred routes, and direct routes in high-density areas. Operational benefits include instrument approaches at new airports and runway ends and enhanced efficiency because of additional approaches. GPS with WAAS augmentation can provide vertical guidance for all future instrument approach procedures—greatly increasing flight safety. In the past, pilots readily accepted and began using satellite-based navigation soon after it was certified as a supplemental means of navigation. Additional user implications and costs are described in Section 18, Avionics.

Transition Period. The transition period begins with the initial operational availability of GPS/

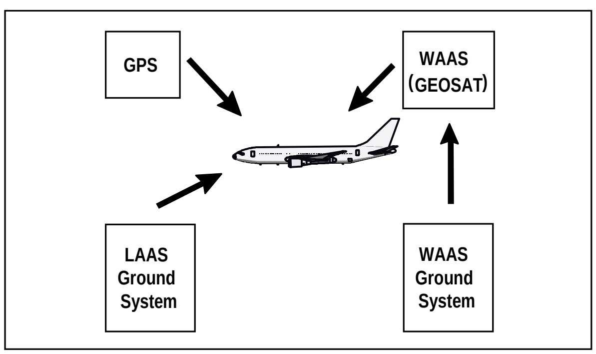

Figure 15-6. Ground-Based Navaids Phased Out

5. The FAA integrated product team and the NAS Information Security Program.
6. FAA cost estimate.
7. Reference: Mission Need Statement 120, Establishment of ILS and Associated Aids, paragraph 9(b)(2), 2 Feb 1993.
8. Under current law, ground-based Navaids can be transferred to nonfederal sponsors who can continue to operate them. However, the FAA needs to recover valuable VHF spectrum to use for other safety-critical services.

WAAS and associated avionics in 2000. Users must have time to recoup their investment in current avionics, and the FAA must have time to develop and publish instrument approach procedures for use with the new technology. A reasonable compromise must be reached between the FAA's desire for a rapid transition and the aircraft operator's desire to use current equipment as long as possible.

15.2 Summary of Capabilities

The existing ground-based navigation and landing capabilities will evolve to a satellite-based system using GPS and related augmentation systems (see Figure 15-7). GPS/WAAS will become the primary means for en route and terminal navigation and will provide CAT I approach capability to airports. GPS/LAAS will provide CAT II and III precision approaches to selected airports. LAAS will also provide CAT I approaches to airports outside WAAS coverage and to a few high-activity airports. As WAAS/LAAS coverage extends throughout the NAS, the ground-based navigation and landing systems will be phased down, leaving sufficient Navaids to support principal air routes and instrument approaches at high-activity airports, should there be a GPS/WAAS service outage.

In its initial phase, WAAS will provide a functional verification system for developing test and evaluation procedures and conducting WAAS system-level testing and operational testing. During this time, GPS can be used for en route navigation and precision approaches in a limited coverage area; however, some additional procedural or operational restrictions may be necessary. Subsequent phases will incorporate additional ground hardware, software upgrades, geosatellites, and improved operational control until WAAS FOC is achieved. WAAS will then satisfy requirements for using GPS for departure, en route, and terminal area navigation and for CAT I precision approaches. The operational and procedural restrictions initially imposed will not be necessary.

LAAS is expected to also provide the all-weather capability needed for precise airport surface navigation. A single LAAS will provide CAT II/III precision approach capability to all runways at an airport. LAAS capability and deployment is independent of WAAS.

15.3 Human Factors

Until now, only a relatively few users, equipped with flight management computer systems or Loran-C, had a flexible, point-to-point navigational capability. In the immediate future, however, any aircraft equipped with GPS or WAAS avionics will have the capability to navigate directly between any two points, independent of Navaids or traditional published routes.

Pilots seeking to take full advantage of this direct routing capability pose a significant challenge to the air traffic control (ATC) system and to controllers, who are tasked with ensuring safe separation between aircraft while facilitating efficient traffic flow. New procedures, automation tools, and training will be necessary to help controllers

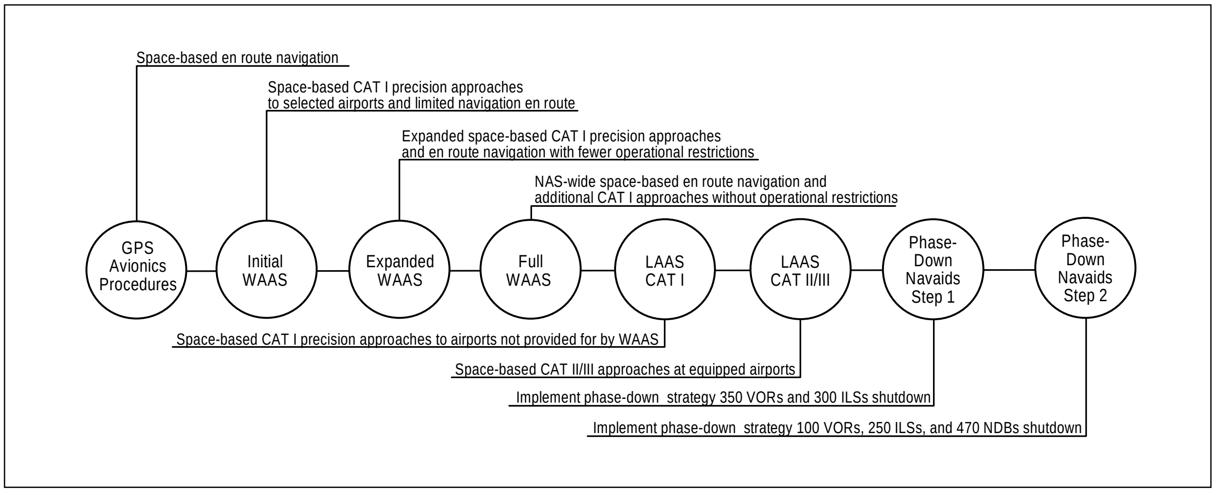

Figure 15-7. Navigation and Landing Capabilities Summary

and pilots manage these capabilities safely and efficiently.

New cockpit displays, including moving maps and cockpit display of traffic information (CDTI), are either available or in development. Traditional fixes used by controllers and pilots will be replaced by pilot-defined waypoints. The georeferences for navigation and surveillance will change. Additionally, new GPS-based instrument approach procedures are being developed. The Safe Flight 21 Program is intended to provide the means for developing and/or testing the equipment features and the pilot and controller procedures needed to realize the full benefits of GPS/WAAS and LAAS.

15.4 Transition

The navigation and landing transition schedule is shown in Figure 15-8. Specific activities associated with the navigation and landing architecture are:

- Safe Flight 21 Program demonstration of prototype LAAS at demonstration sites
- GPS/WAAS backup analysis
- WAAS deployment (IOC/FOC)
- LAAS deployment
- Ground-based Navaids phase-down strategy.

15.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for navigation, landing, and lighting systems architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 15-9.

15.6 Watch Items

The evolution of the navigation architecture depends on policy decisions, regulations, equipment certification, standards development, and performance factors. These include:

- Availability of GEOSATs (Additional satellites are needed for WAAS to achieve its full operational capability. A study will evaluate the options available for providing the additional satellites. Funding to lease the additional satellite capability is programmed to begin in FY02 or 03.)
- Studies on redundant Navaids (The FAA is studying what redundant navigational capability may be required in the event of a GPS outage.)
- Certified, affordable avionics

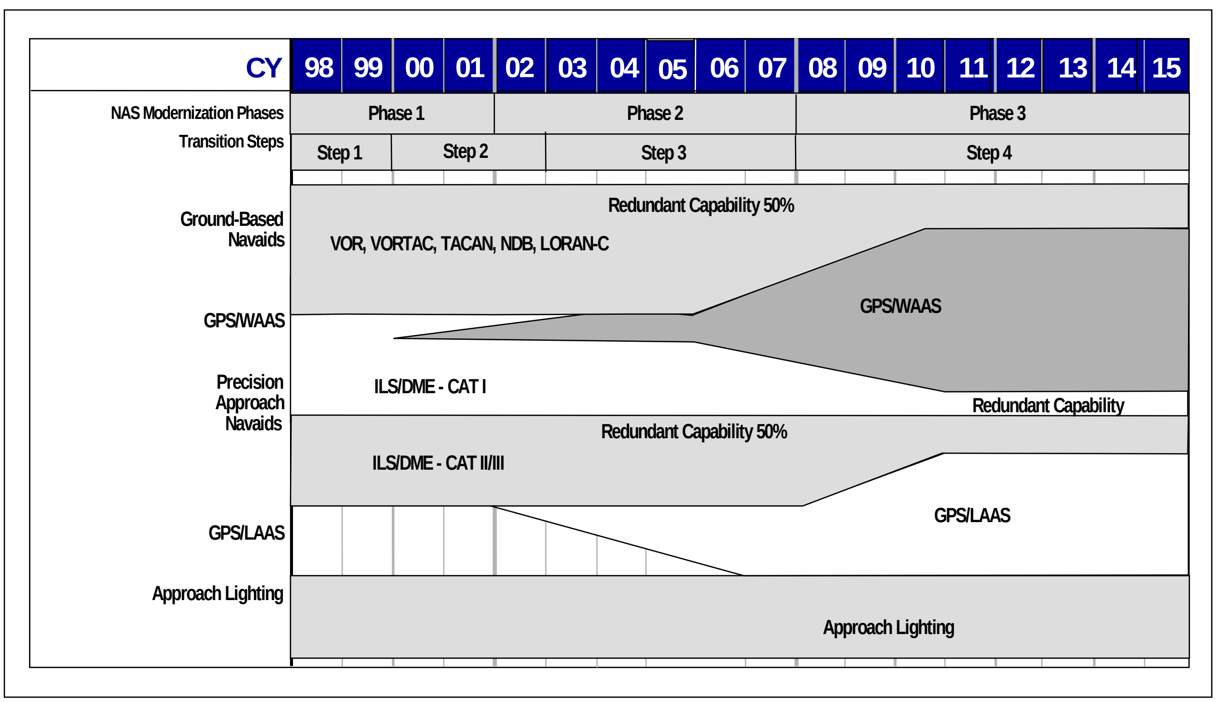

Figure 15-8. Navigation and Landing Transition

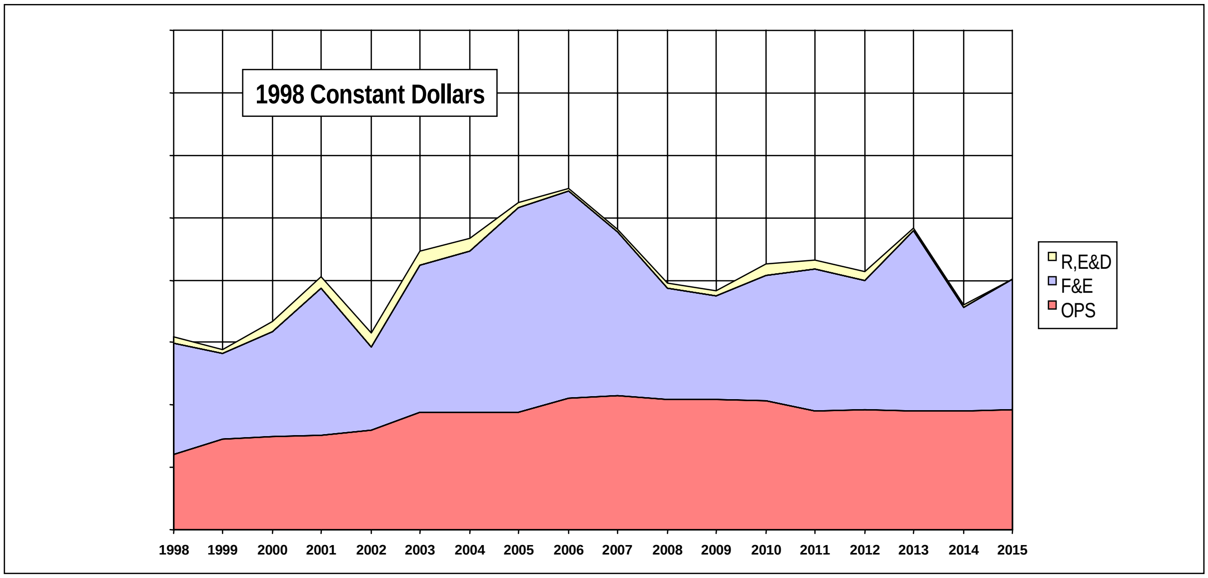

Figure 15-9. Estimated Navigation Costs

- Policies on carrying redundant equipage
- Programmatic issues
  - WAAS performance
  - LAAS/WAAS schedule
  - Development of LAAS standards
  - Second civil frequency
- Policy issues:
  - Notice of proposed rulemaking for airspace minimum avionics equipage and required navigation performance
  - Reuse of frequency spectrum presently dedicated to navigation for other aeronautical services
  - Continuation or shutdown of nonfederal Navaids
  - Rate and willingness of users to equip with WAAS/LAAS avionics
- International interoperability:
  - International agreements and standards for satellite-based systems to ensure global interoperability[9]
  - Operational procedures.

9. The United States leads or actively participates on several ICAO Air Navigation Commission (ANC) panels. Panel members develop international standards, which are approved by the Council, ICAO's governing body. It is essential to NAS architecture development to fully incorporate these international standards. Within the navigation area, recent standardizing efforts include work on: airspace planning methodology for determining separation minima by the Review of the General Concept of Separation Panel (RGCSP); standards and recommended practices (SARPs) development by the All Weather Operations Panel (AWOP); and long-term requirements and SARPs developed by the Global Navigation Satellite System Panel (GNSSP).

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16 SURVEILLANCE

Following are definitions of the terms used in the surveillance architecture:

Independent Surveillance: The use of primary radar to independently detect and determine the range and azimuth (2-dimensional position) of aircraft by means of reflected radar energy. Airport surface detection equipment (ASDE) primary radars are used to determine the position of aircraft and vehicles operating on airport taxiways and runways. Primary radar surveillance is *independent* because aircraft or ground vehicles need not be equipped with any enabling avionics to be detected.

Cooperative Surveillance: The use of secondary surveillance radar (SSR) to determine the position, assigned beacon code (4,096 codes are currently available), and in most cases, the barometric altitude of an airborne aircraft by interrogation of a transponder onboard the aircraft. Because the aircraft must be equipped with a transponder, SSR technology is deemed to provide *cooperative* surveillance. Mode-3/A transponders reply with only the assigned code. Mode-3/C transponders (the most common type) reply with both assigned code and altitude. Mode-Select (Mode-S) transponders reply with assigned code and barometric altitude to all SSR interrogators and also include a discrete, permanently assigned address when replying to Mode-S interrogators. The Mode-S system also permits additional data to be exchanged between aircraft and Mode-S radars.

Automatic Dependent Surveillance:

- *Automatic Dependent Surveillance Broadcast (ADS-B):* The function on an aircraft or surface vehicle that broadcasts position, altitude, vector, and other information for use by other aircraft, vehicles, and ground facilities.
- *Automatic Dependent Surveillance (ADS):* The use of ADS-B information by ground facilities to perform surveillance of airborne aircraft and aircraft or vehicles operating on the airport surface. This technology is deemed to provide *dependent* surveillance because it relies totally on each aircraft to determine its position (by means of the onboard navigation system) and report that position (and other data) via ADS-A or ADS-B communications equipment.
- *Automatic Dependent Surveillance Addressable (ADS-A):* A different form of ADS, designed to support oceanic aeronautical operations, based on one-to-one communications between aircraft providing ADS information and a ground facility requiring receipt of ADS reports. The term "ADS-A," as used here is equivalent to "ADS" as discussed in International Civil Aviation Organization (ICAO) documentation.

Overview

The concept of operations (CONOPS) calls for surveillance of all controlled aircraft in the domestic airspace, using ADS and radar systems. ADS will be based on aircraft latitude/longitude position and velocity reports from the aircraft's navigation system, barometric altitude, as well as short-term intent information (next way points). The CONOPS emphasizes the importance of ADS for both air-air and ground-based surveillance and extending instrument flight rules (IFR) separation services to nonradar areas of domestic airspace. The future cockpit applications for ADS-B include:

- Pilot situational awareness
- Separation assurance
- Limited shared responsibility for separation
- Safer airport surface operations in reduced visibility conditions.

The surveillance architecture will support Free Flight, provide increased surveillance coverage, improve safety, and increase airspace capacity. Changes in surveillance are designed to open airspace, allow for more direct routings, and increase NAS flexibility to meet growing demand.

The current domestic surveillance system consists of primary and SSRs that are used to detect aircraft and determine their position and identity. Air traffic control (ATC) automation systems process the radar data for display to air traffic controllers. Controllers use these data to separate aircraft flying under IFR from other aircraft, obstacles, terrain, and special use airspace and to provide weather advisory services. Weather detection functions provided by today's radar surveillance systems are discussed in Section 26, Aviation Weather.

The NAS surveillance architecture will use primary radars with digital technology for terminal airspace, but primary radars will be phased out of en route airspace. SSRs with selective interrogation (SI) capability will be used in both en route and terminal airspace. The SI capability allows the ATC automation, when modified, to utilize the unique Mode-S transponder identification code permanently assigned to an aircraft; eliminates false data from the controller's display; and supports use of Mode-S data link to provide traffic information service (TIS) to the cockpit.

The Mode-S data link will also enable use of a future Ground-Initiated Communications Broadcast (GICB) message. The accuracy of the position and intent information received from the aircraft via the GICB message is expected to significantly improve target tracking and the performance of controller tools such as conflict alert, conflict probe, and the Final Approach Spacing Tool (FAST). The GICB will capture the aircraft's ADS-B information in concert with the beacon interrogation. This allows independent verification of position, supports separation between ADS-B aircraft and those not equipped (especially important during transition), and allows the FAA to use the SSR network as part of a larger network of ground listening stations.

If enough users equip with ADS-B avionics, ADS-B for air-air surveillance will be implemented in domestic and oceanic airspace. Pilots are expected to use ADS-B air-air surveillance for situational awareness. In oceanic airspace, ADS-B may be approved as a means for pilots to conduct in-trail climbs, descents, and passing maneuvers.

If enough users equip, compatible ADS ground systems, which leverage off of the avionics equipage, will be implemented in domestic airspace (see Figure 16-1). Due to the characteristics of ADS-B (frequent broadcast of position), ADS-B-based surveillance is expected to be the most accurate form of surveillance, potentially allowing minimum aircraft separation standards to be reduced. These surveillance improvements are expected to help expedite traffic flow in the NAS.

The CONOPS calls for implementing surveillance capability in oceanic airspace. In today's oceanic airspace environment, "procedural" separation between aircraft is managed by means of high frequency radio position reports provided verbally by pilots to controllers, indirectly through a third-party commercial communications provider. No means of direct oceanic surveillance is currently available. Consequently, the required lateral/longitudinal separation between aircraft in oceanic airspace is very conservative (between 60 and 80 nmi), and the capability to approve route and altitude changes is constrained.

ATC surveillance in oceanic airspace will be based on ADS-A reports to oceanic controllers via satellite communications (SATCOM), high frequency data link (HFDL), or other subnetworks. The reports, which are derived from Future Air Navigation System (FANS-1A) or aeronautical telecommunications network (ATN) avionics, include barometric altitude, latitude/longitude position, velocity, and short-term intent information (next way points). Ground equipment and automation will display the aircraft position and track to oceanic controllers, enabling current lateral/longitudinal separation standards to be reduced.

16.1 Surveillance Architecture Evolution

To ensure high availability of services in domestic airspace, the surveillance architecture provides at least two complementary means of surveillance. For example, if the aircraft navigational system associated with ADS-B malfunctions, beacon interrogation will continue to provide cooperative surveillance as a basis for separation. In oceanic airspace, surveillance will be provided by ADS-A communicated via SATCOM, HFDL, or other subnetworks.

Surveillance System Domains

Surveillance systems support four NAS domains: (1) en route, (2) oceanic, (3) terminal, and (4) tower/surface.

En Route Domain. A new SSR air traffic control beacon interrogator (ATCBI-6) with SI and the GICB feature will be installed at all ATCBI-4 and ATCBI-5 en route radar sites.

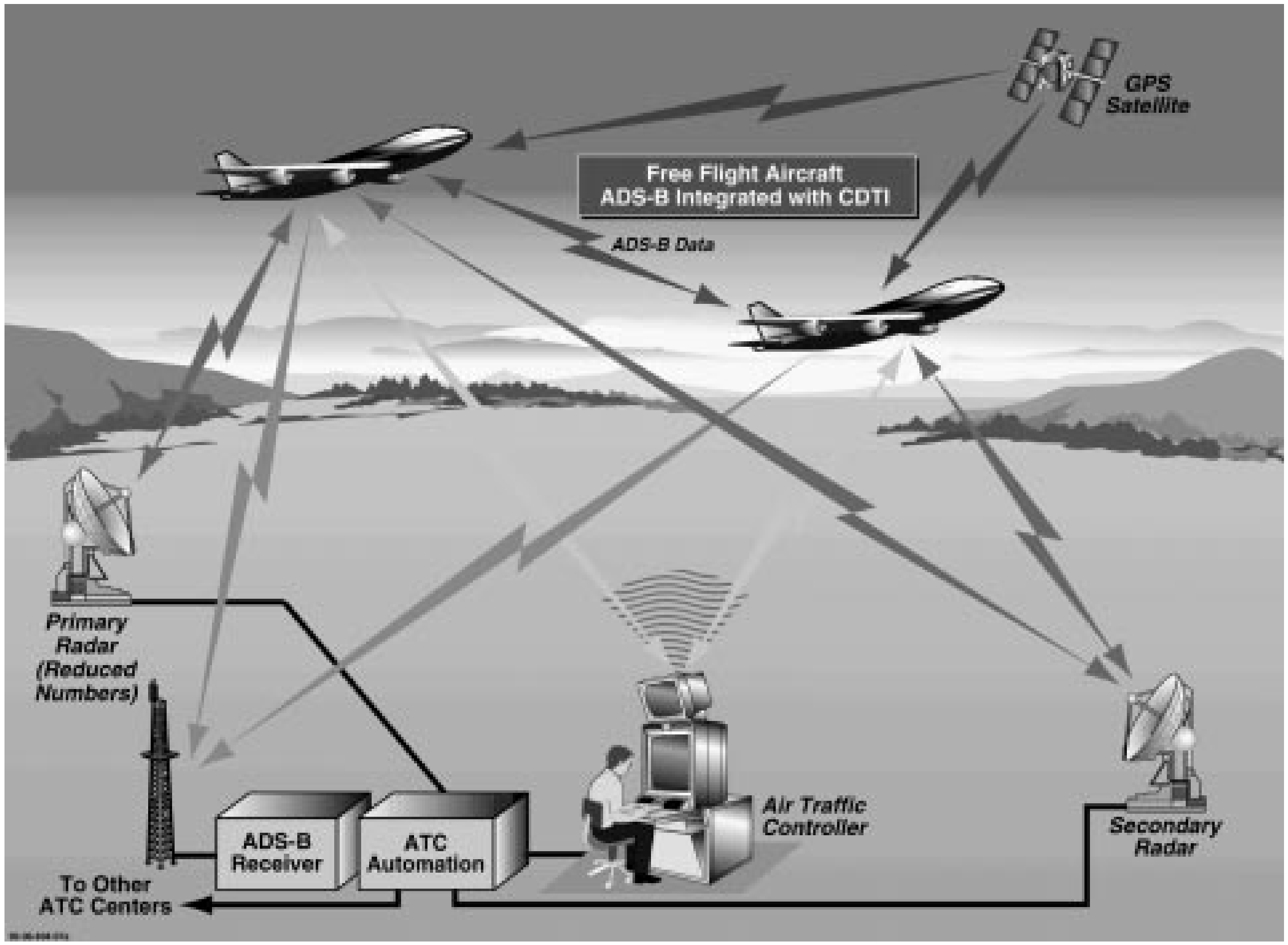

Figure 16-1. Proposed Surveillance System Architecture

The ATCBI-6 will work with Mode-3/A and 3/C transponders, enabling the ATC system to remain compatible with all users as they transition to ADS-B avionics. The Mode-S SSR will remain in service at 25 sites. They will be configured to provide TIS, a Mode-S data link service that provides automatic traffic advisories to properly equipped aircraft.

The SI capability of the Mode-S and ATCBI-6 radars will enable the air route traffic control centers (ARTCCs) to use Global Positioning System (GPS) data for surveillance via GICB. ADS capability will also be installed. The continued use of SSRs will enable the ATC system to maintain full service in domestic en route airspace whenever there is any difficulty with the ADS system. Continued use of SSRs also permits an extended transition period for general aviation (GA) in low-altitude airspace. Primary en route radars will be phased out of interior areas, except for those needed by the Department of Defense (DOD), or other agencies.

Oceanic Domain. ADS based on ADS-A will be implemented in oceanic airspace. SATCOM is emerging as the primary communications link for ADS-A and other oceanic communications, with HFDL likely to be used as an alternative source.

Terminal Domain. A new digital, combined primary/SSR system (airport surveillance radar (ASR)-11) will be deployed to complement the ASR-9/Mode-S system. The Mode-S will be configured to provide TIS. All ASR-11 integrated beacons will be upgraded to include SI and GICB capability. Terminal radar approach control (TRACON) facilities will begin to use ADS for surveillance. All three means of surveillance (primary radar, secondary radar, and ADS) will be retained in the terminal domain.

Tower/Airport Surface Domain. ASDE-3 will receive a service life extension. A new surface surveillance capability with conflict detection capability will be installed at additional airports. ADS capability for surface surveillance will also be installed. The accuracy of Wide Area Augmentation System (WAAS)- and Local Area Augmentation System (LAAS)-derived ADS-B (with LAAS taking precedence) is expected to enable the ADS system to support substantial airport surface operations in reduced visibility conditions. The airport surface ADS system will also feature a multi-lateration capability that uses aircraft transponder replies, triggered by the terminal SSR or local interrogators, to determine the identification and the position of non-ADS-B aircraft on the airport surface. Adding multi-lateration provides an alternate means of surveillance in absence of ASDE.

16.1.1 Surveillance Architecture Evolution—Step 1 (1998)

En Route Domain. Various models of air route surveillance radar (ARSR-1, -2, -3, and -4) and several military fixed position surveillance (FPS) (military primary radar) types are used to provide primary radar surveillance for the ARTCC. These radars are positioned to support major airways and provide surveillance coverage within a 200- to 250-mile radius with 10- to 12-second update rates. Except for the ARSR-4, many of these radars have been in service for 30 years and are costly to operate and maintain. The ARSR-4 radars in the continental United States and the FPS-117 radars in Alaska are jointly used by the FAA and the Air Force for ATC and air defense, respectively.

Two types of SSRs are used: the ATCBI-4 and -5 and the Mode-S. Nearly all SSRs are co-located with en route primary radars and operate at equivalent ranges and update rates. Twenty-two SSRs operate as stand-alone radars supporting ARTCCs. The ATCBI-4s and -5s are reaching the end of their service lives and will be replaced.

Oceanic Domain. In current operations, pilot position reports are made to a commercial service via high frequency (HF) voice communications. They are then forwarded to FAA oceanic ATC centers where the reported positions are displayed to controllers. Some pilot position reports are currently being transmitted from FANS-1/A-equipped aircraft via satellite data link using controller-pilot data link communications (CPDLC) messages to some oceanic sectors.

Terminal Domain. Three models of airport surveillance radar (ASR-7, -8, and -9) are positioned on airports to provide surveillance coverage (55-mile radius with a 5-second update rate) for TRACONs. The analog ASR-7 and -8 radars, which have been in service since the 1970s, are incompatible with the future digital terminal automation system, the Standard Terminal Automation Replacement System (STARS). Two types of SSRs are used in the terminal domains: the ATCBI -4 and -5 and the Mode-S. They are all co-located with ASRs and operate at equivalent ranges and update rates.

Tower/Airport Surface Domain. ASDE radars, used to provide primary radar surveillance of aircraft and vehicles on airport runways and taxiways to air traffic control towers (ATCTs), are being installed at the 34 busiest U.S. airports. The Airport Movement Area Safety System (AMASS), being installed at the same airports, works in conjunction with the ASDE-3 to alert tower controllers of impending runway incursions and other ground traffic problems. A parallel runway monitor (PRM) radar has been commissioned at the Minneapolis and St. Louis airports to monitor aircraft on approach to closely spaced parallel runways (separated by less than 4,300 feet).

16.1.2 Surveillance Architecture Evolution—Step 2 (1999–2002)

En Route Domain. The weather and radar processor (WARP) will enable weather data from the next-generation weather radar (NEXRAD) to be displayed to en route controllers on the display system replacement (DSR). This capability will allow en route primary radars to be shut down. Data from the ARSR-1, -2, -3, - 4, and FPS primary radars will not be used by FAA after WARP reaches full operating capability (FOC) (i.e., provides NEXRAD data to DSR) in early 2000. However, the long-range primary radars that support Department of Defense (DOD) operations (i.e., FPS-117 and ARSR-3 and -4 radars) may remain in use as required by DOD or other agencies. An ARTCC may receive data from suitably located terminal radar equipment, as needed, for supplemental coverage and gap filling.

The en route SSRs (ATCBI-4 and -5) will be replaced with a new ATCBI-6 with SI capability. ARSR-1, -2, and -3 and FPS site equipment and components, including the radar towers and pedestals, rotary joints, and shelters will require modification or replacement to allow compatibility with an SSR-only configuration.

Oceanic Domain. Oceanic sectors will continue to receive pilot position reports from FANS-1/A-equipped aircraft via satellite data link using CPDLC messages, as well as from HF voice communications.

Terminal Domain. The ASR-9 radars will receive a service life extension. The ASR-7 and -8 radars will be replaced by new digital ASR-11 radars delivered with a new monopulse SSR. Digital radars are required for interoperability with STARS.

To take early advantage of the information available in ADS-B avionics, the architecture plans for all SSRs to be equipped with a selective interrogation capability. The Mode-S sensors currently paired with ASR-7 and -8 radars will be "leap-frogged" to ASR-9 sites, so that all ASR-9s will be paired with SI-capable Mode-S SSRs. Mode-S sensors will receive a service life extension. All SSRs will remain compatible with the older Mode-A/C transponders, thus allowing time for aircraft to transition to ADS-B avionics.

TIS, a Mode-S data link service that provides automatic traffic advisories to properly equipped aircraft, will be implemented during this period. Pilots will be able to request and receive a display of nearby traffic. The relative range, bearing, and altitude (if known) and a "proximate" or "threat" classification of nearby aircraft will be displayed. This service will help pilots "see and avoid" other aircraft.

Tower/Airport Surface Domain. Installation of ASDE-3 radars to detect aircraft and vehicles on runways and taxiways will be completed at 34 airports. AMASS, which uses data from the terminal automation and ASDE-3 systems to alert tower controllers to potential traffic conflicts, will be installed at the same airports during this period. Installation of a new surface surveillance conflict detection system will begin at additional airports. This capability will further reduce the probability of traffic conflicts on airport surfaces and increase the efficiency of aircraft operations. Installation of PRMs at four additional airports is planned.

Additional Information. The user aviation community is currently investigating ADS-B for air-air surveillance. Several technologies—including 1090 MHz (Mode-S) squitter, self-organizing time division multiple access (STDMA) (also known as VHF digital link-Mode 4 or VDL-4), and Universal Access Transceiver (UAT)—are being tested. During this period Safe Flight 21 ADS concept demonstrations will be conducted to determine if and how ADS-B and ADS would operationally benefit users and the FAA and which technology is most suitable for this purpose.

If enough users equip with ADS-B avionics, the FAA will develop and install a compatible ADS ground system. In domestic airspace, ADS will depend upon the aircraft to automatically and frequently broadcast its position and velocity using ADS-B avionics.

Surveillance tracks derived from ADS-B data are expected to be more accurate than radar-derived tracks, thus improving the performance of controller decision support systems (DSSs) such as conflict probe, trial flight planning (a capability that evaluates pilot requests for revised flight paths for potential conflict with other flights), and FAST. Such improvements will help expedite traffic flow in the NAS.

Should users equip, ADS-B for air-air surveillance will be implemented in domestic and oceanic airspace. ADS-B is anticipated to support air-air surveillance by means of a cockpit display of traffic information (CDTI) that shows the position of all ADS-B-equipped aircraft nearby as a reference for tactical maneuvering, self-separation, and station-keeping. This will greatly enhance situational awareness in the cockpit. In domestic airspace, pilots are expected to use ADS-B air-air surveillance for situational awareness and limited shared responsibility for separation. These capabilities are expected to primarily benefit air carrier and cargo operations, but would be helpful to all of aviation as well. ADS-B avionics will not be required to operate in the NAS. In oceanic airspace, ADS-B may also be approved as a means for pilots to conduct in-trail climbs, descents, and passing maneuvers.

16.1.3 Surveillance Architecture Evolution—Step 3 (2003–2006)

En Route Domain. The Mode-S and ATCBI-6 SSRs will be upgraded with the All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX) surveillance and weather message transfer protocol that was developed by the European Civil Aviation States to standardize data communications between surveillance and automation systems. This upgrade will allow the aircraft navigational system and waypoint data received in GICB replies to be processed. Mode-S sensors will receive a service life extension.

The ARTCC automation system will be upgraded to use GICB and ADS data for controller tools and displays (see Section 19, En Route). Installation of the ATCBI-6 SSRs will be completed.

Oceanic Domain. Installation of communications, and automation equipment to support ADS-A will begin. Current longitudinal separation standards between suitably equipped aircraft could be reduced in some areas by using ADS-A and other controller tools.

Terminal Domain. Mode-S SSRs will be upgraded with ASTERIX. The ASR-11's SSR will be upgraded with SI capability and the ASTERIX standard interface protocol. This will enable the ASR-11 SSR to send the aircraft position, velocity, and next waypoint data received via the GICB message to the STARS automation. STARS will be upgraded to use GICB and ADS data for controller displays (see Section 23, Terminal).

Tower/Airport Surface Domain. Installation of the new surface surveillance and conflict detection system will continue. If enough users equip with ADS-B avionics, installation of about 600 passive ADS ground stations with multi-lateration capability for airport surface surveillance will begin at approximately 150 airports. The multi-lateration capability enables the ADS system at an airport to determine the position of aircraft equipped with Mode-A/C/S transponders.

ADS-B avionics, which use WAAS and LAAS information, will provide the ADS source to precisely monitor the surface movement of ADS-B-equipped airport traffic. Due to its expected accuracy, LAAS is preferred for surface surveillance. The airport surface ADS system will interface with the STARS automation and displays to provide precision surface surveillance and warn tower controllers of impending runway incursions and other ground traffic problems. The STARS automation system will be capable of processing the ADS data. AMASS will receive a service life extension to ensure its viability.

16.1.4 Surveillance Architecture Evolution—Step 4 (2007–2010)

En Route Domain. If enough users equip with ADS-B avionics, the architecture plans for the installation of 20 passive ground stations in airspace not covered by radar. This capability will provide extended en route surveillance coverage for ADS-B-equipped aircraft. An additional 96 passive ADS ground stations will be installed in the en route airspace covered by radar.

Oceanic Domain. Implementation of ground-based and airborne communications and automation equipment to support ADS-A and ADS-B air-air surveillance will continue. Oceanic airspace users will benefit through greater flexibility, increased user-preferred routes and climbs, and greater capacity.

Terminal Domain. If enough users equip, passive ADS ground stations will be installed to provide ADS for up to 150 terminal areas. Target data from the ADS ground stations will be processed for display on TRACON controller workstations. The ADS system will also be used for monitoring instrument approaches to closely spaced parallel runways.

Tower/Airport Surface Domain. AMASS functionality will be incorporated into the tower automation system and installation of ADS ground stations will be completed. Installation of the new surface surveillance and conflict detection system also will be completed.

16.1.5 Surveillance Architecture Evolution—Step 5 (2011–2015)

En Route Domain. En route surveillance will be provided by SSRs and ADS. FAA-funded replacement of primary en route radars is not contemplated.

Terminal Domain. A next-generation terminal radar (multipurpose airport radar (MPAR)), which incorporates primary radar, SSR, and terminal Doppler weather radar capabilities, will begin to replace the existing systems starting about 2015.

Tower/Airport Surface Domain. ASDE systems will be decommissioned at the end of their service lives. Surface surveillance will rely on ADS surveillance with multi-lateration or other more cost-effective technologies for preventing runway incursions.

16.2 Summary of Capabilities

The evolution of surveillance capabilities is depicted in Figure 16-2**.**

Air Surveillance

The ADS-B concept is expected to provide an important air-air surveillance capability. Aircraft equipped to receive ADS-B transmissions will be able to display the position of all ADS-B-equipped aircraft in their proximity on CDTI displays. This capability will improve aircrew situational awareness, increase approach and departure efficiencies, and improve oceanic maneuvering. It

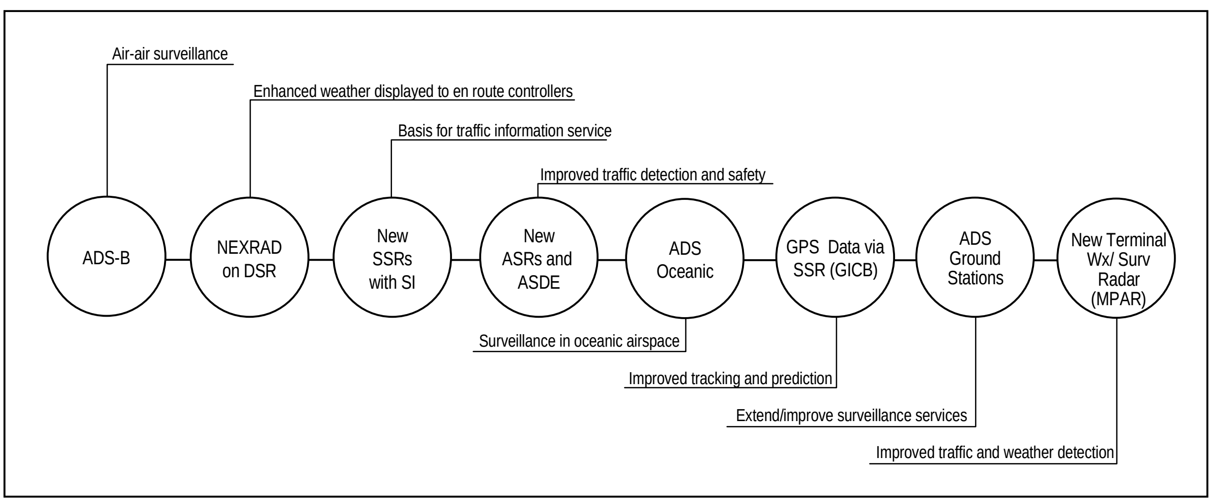

Figure 16-2. Surveillance Capabilities Summary

PART III

will enable pilots to assume responsibility for separation in certain circumstances.

Air Traffic Control System

Weather data from next-generation weather radars (NEXRAD) will be available to en route controllers via WARP, enabling long-range primary radars to be phased out. Primary radars will continue in use in terminal airspace and for airport surface surveillance. SSRs will continue in use in both terminal and en route airspace.

ADS will be introduced to provide a surveillance capability in oceanic airspace. The capability is based upon ADS-A, which uses position reports transmitted from FANS-1/A- or ATN-equipped aircraft via SATCOM, HFDL, or other subnetworks.

The terminal primary radar system will become all-digital with significantly improved capabilities, such as better detection of small aircraft at low altitudes and dedicated weather detection and processing. Primary radar for surface surveillance, coupled with conflict prediction capability, will be installed at a significant number of airports to improve surface operations and safety.

All SSRs will have an SI with GICB capability to elicit position and velocity (presumably GPS-derived) from the navigation system of suitably equipped aircraft via the Mode-S transponder. The resultant tracking accuracy will improve the performance of controller automation tools, such as conflict probe and requested flight path (trial planning), which support pilot routing and rerouting preferences.

Implementation of ADS in the domestic airspace (based on ADS-B) will enable surveillance services to be extended to new areas and improved in existing areas. ADS will support surface operations, thereby improving airport utilization during reduced visibility conditions. In conjunction with AMASS, ADS will increase protection against runway incursions. ADS will also improve airport utilization by providing the capability to monitor simultaneous approaches to closely spaced parallel runways in all weather conditions.

16.3 Human Factors

The surveillance systems themselves are not expected to require significant human factors engineering. However, the addition of the new surveillance capabilities (such as those associated with GICB messages and ADS-B, data and target fusion, and new mapping techniques) is expected to levy considerable human factors requirements on the ATC automation displays, aircrews, and controllers. The associated human factors effort will focus on the impact of new surveillance technologies, equipment, and methods on pilots, controllers, and maintainer interfaces, including:

- Identifying informational requirements and integrating information from new or multiple sources (such as the integration of ADS surveillance data with other radar data) in ways to facilitate development or modification of essential DSSs
- Application of reduced minimum separation standards for the controller and aircrews
- Prototyping changes to tasks and procedures that take advantage of new surveillance capabilities (such as SI and increased surveillance accuracy derived from GPS data).

The surveillance capabilities envisioned for the future (such as authorizing an aircrew to use ADS-B CDTI for self-separation) will require development of suitable cockpit displays and procedures. Controllers will require DSS tools to assist them in monitoring and appropriately interceding to ensure safe operations.

16.4 Transition

Primary Radars

Information from en route primary radar systems will not be used for ATC after NEXRAD weather data become available on ARTCC controller displays. It is expected that those radars required by DOD (ARSR-4s, some interior radars, and the FPS-117 radars in Alaska) will be supported by DOD until the end of service life, although current agreements call for FAA maintenance. Terminal primary radars will be retained to provide independent surveillance. The principal transitions are:

- Complete deployment of ASDE-3, ARSR-4, and ASR-9 equipment
- Replace ASR-7 and -8 radars with ASR-11

- Decommission the primary en route radars (ARSR -1, -2, -3, FPS) not required in accordance with FAA/DOD joint agreements
- Deploy new airport surface movement detection equipment with conflict prediction capability
- Perform a service life extension for ASR-9 and ASDE-3/AMASS radars
- Decommission any remaining en route primary radars (ARSR-4, FPS-117)
- Replace ASR-9 and -11 radars with a new terminal radar that includes SSR and terminal Doppler weather radar (TDWR) capability.

Secondary Radars

The SSRs will be retained to provide cooperative surveillance compatible with Mode-A/C transponders and redundancy in case dependent surveillance is interrupted. All SSRs will feature SI capability in order to utilize GICB transponder replies. The principal transitions are:

- Deploy remaining PRM systems
- Upgrade ASR-11 beacon with SI capability
- Replace en route ATCBIs-4 and -5 with ATCBI-6
- Leapfrog Mode-S from ASR-7 and -8 sites to ASR-9 sites
- Upgrade SSRs with GICB and ASTERIX capabilities
- Perform a service life extension for Mode-S radars.

Automatic Dependent Surveillance

ADS in domestic airspace will be based on ADS-B; in oceanic airspace, it will be based upon ADS-A. The Safe Flight 21 program is intended to support development and evaluation of ADS ground stations and the automation processing and display of ADS-derived information. If enough users equip with ADS-B avionics, a successful Safe Flight 21 program is expected to result in deployment of ADS ground stations. Figure 16-3 shows the transition schedule for the ADS systems. The principal transitions are:

- Install oceanic ADS-A capability

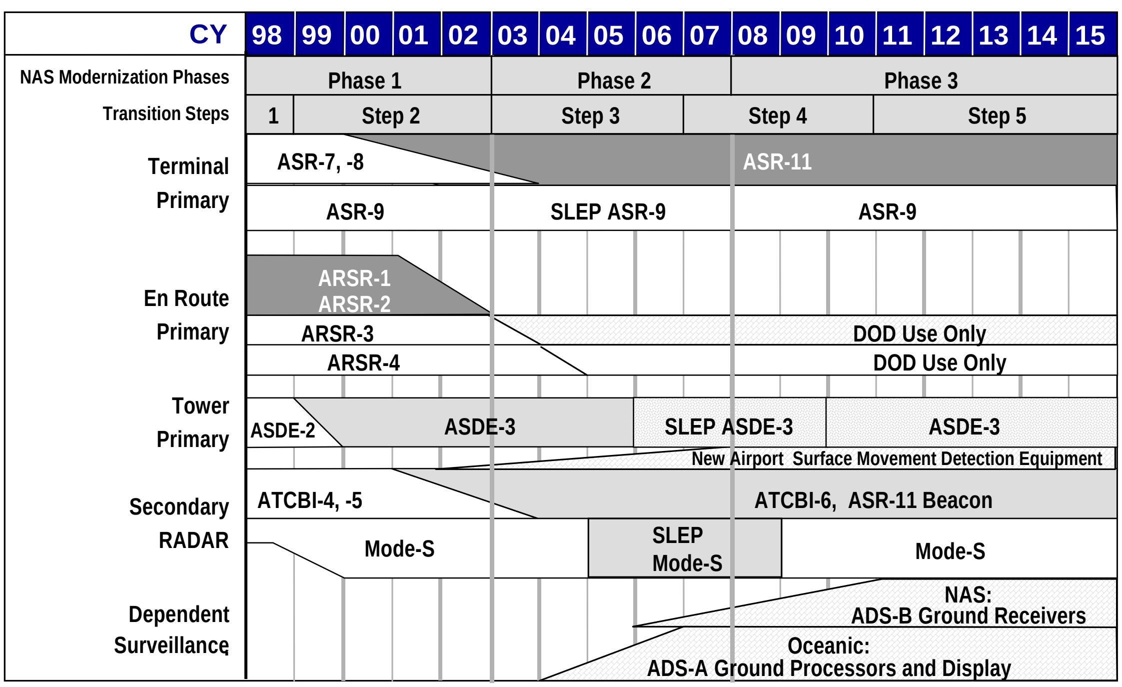

Figure 16-3. Major Surveillance Systems Transition

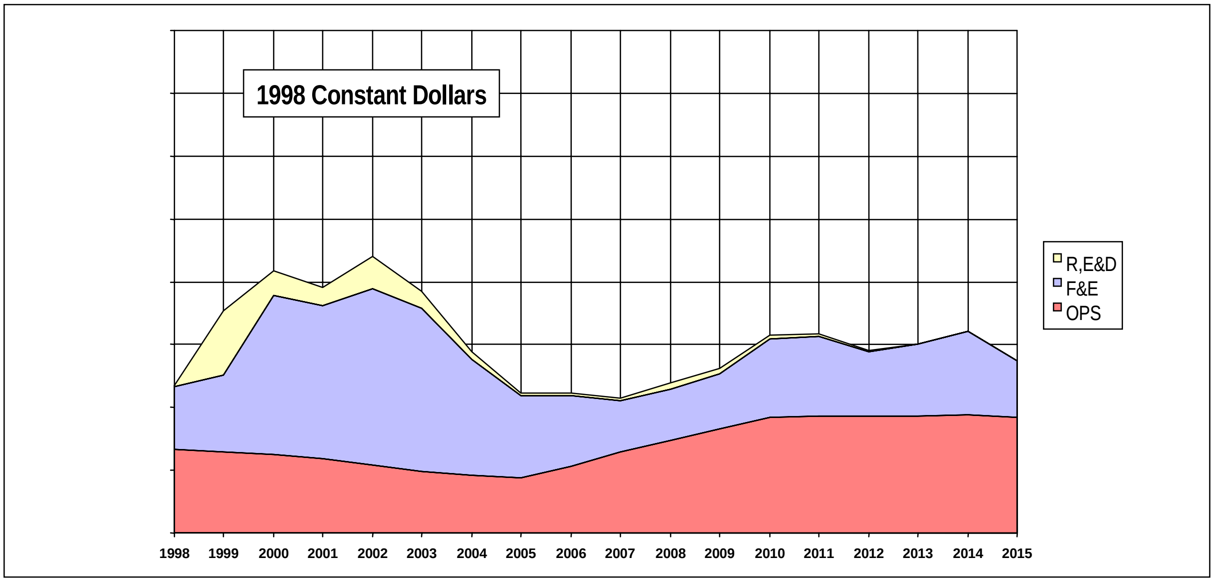

Figure 16-4. Estimated Surveillance Costs

- Complete ADS-B, Traffic Alert and Collision Avoidance System (TCAS), and CDTI standards for air-air surveillance
- Based on air-air surveillance, provide enhanced approach/departure and oceanic maneuvering services
- Develop ADS ground stations and improved surveillance systems via the Safe Flight 21 ADS-B program
- Deploy passive ADS ground stations:

  –To extend en route surveillance coverage to new areas

  –To en route, terminal, and airport surface locations throughout the NAS.

Other Surveillance Support:

- Complete AMASS implementation
- Perform service life extension for ASDE-3 and AMASS.

16.5 Costs

FAA estimates for research, engineering, and development (R,E&D), facilities and equipment (F&E), and operations (OPS) life-cycle costs for surveillance architecture from 1998 through 2015, are presented in constant FY98 dollars in Figure 16-4.

16.6 Watch Items

Decommissioning long-range primary radars depends on the availability of a WARP-provided NEXRAD weather data presentation on the new ARTCC displays now being installed. The WARP program is on schedule to be fully operational in all ARTCCs during Step 2.

ADS, based on ADS-A and ADS-B, is the major new ground surveillance capability envisioned for oceanic and domestic airspace, respectively. The initial development and evaluation of ADS, as well as ADS-B for air-air surveillance, depends on a number of significant technological developments involving avionics and ground equipment, and operational demonstrations planned for the Safe Flight 21 program, slated to occur during Step 2. Results of the Safe Flight 21 demonstrations will be subject to evaluation by both the FAA (through the Investment Analysis process) and users to determine subsequent investments and implementation in the NAS. It is evident that FAA and user decisions must be linked, because ADS is dependent on user investment in avionics. Avionics manufacturers are expected to create and integrate GPS-WAAS/LAAS receivers and ADS-B avionics for aircraft slated to participate in Safe Flight 21.

To use aircraft-derived position data for surveillance and tracking, the SSRs must all be configured with SI and ASTERIX in Steps 2 and 3. ATC automation systems will need to be configured to receive and process the enhanced surveillance data.

A major watch item is the rate at which users install ADS-B avionics during Steps 2, 3, and 4. The rate of equipage will be determined by factors such as avionics cost, availability, and perceived user benefits. The realization of expected user benefits, such as improved vectoring and sequencing and flexible routes, will depend on the rate of user equipage, procedural development, and FAA capability to process GPS data provided by aircraft avionics.

This architecture continues to provide surveillance, independent of user equipage with ADS-B. However, the FAA will deploy ADS-B listening (ground) stations as users equip with ADS-B avionics. A long transition period to ADS-B is anticipated. This requires the FAA to continue providing surveillance services using primary and secondary radar.

ADS in oceanic airspace will be based on position reports data linked by satellite, high frequency data link, or other subnetworks to FAA oceanic controllers. Airlines are ordering the FANS avionics needed for navigation and data link reporting via SATCOM. The FAA program to acquire the reciprocal necessary ground equipment and automation capabilities is under consideration.

17 COMMUNICATIONS

The NAS communications architecture provides a plan for achieving reliable, timely, efficient, and cost-effective transfer of information among NAS users and between NAS users and the external environment. It addresses communications technology and standards, telecommunications system integration and partitioning, network operations and management, and transition. The architecture meets the concept of operations (CONOPS) requirement for seamless communications across domains and information sharing among all NAS users. It also provides for the subnetworks needed to support NAS resectorization in the future.

In order to facilitate the NAS architecture planning process, the communications system is divided into three elements: Interfacility Communications, Intrafacility Communications, and Mobile Communications.

- *Interfacility Communications:* Consist of the networks that transmit voice, data, and video information among FAA facilities and that connect to external facilities. Interfacility communications connect with intrafacility communications and mobile communications.
- *Intrafacility Communications:* Consist of the networks that transmit voice, data, and video to users within a facility. Intrafacility networks interface with interfacility networks to connect users within a given facility to users in other facilities or to mobile users.
- *Mobile Communications:* Consist of networks that transmit voice and data among mobile users. These networks interface with interfacility networks to provide communications paths between mobile users and users within a facility. Two types of mobile communications networks are used in the NAS: air-ground communications networks that support air traffic control and ground-ground networks that support maintenance and administrative activities.

Information exchange among NAS users involves one or more of these elements. Air-ground communications, for example, use all three elements of the communication system. Various applications of the communications system are further described in Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface. The data link system and services are described in Section 17.1.4, Data Link Service.

17.1 Communications System Evolution

The FAA has traditionally considered communications networks in terms of air-ground voice communications, ground-ground operational voice and data communications, and agency (administrative) voice and data communications. The communications architecture proposes to integrate these networks to improve interoperability, quality of service, network security, and survivability while reducing the cost per unit of service.

Most ground-ground transmission systems will be consolidated within a common network infrastructure that will integrate administrative and operational communications systems for interfacility transmission of voice, data, and video.

The NAS will migrate to a digital telecommunications infrastructure to take advantage of new technology and the growing number of digital services. The telecommunications infrastructure will also support current analog voice switches and legacy protocols.

The domestic air-ground system will migrate to digital technology for both voice and data communications. Oceanic communications will migrate to International Civil Aviation Organization (ICAO)-compliant aeronautical telecommunication network (ATN) data link applications using high frequency (HF) and satellite-based links.

17.1.1 Interfacility Communications System Evolution

The NAS interfacility system is expected to lower communications costs while providing qualitative service improvements and future growth capacity. A decisive change at this time is critical for two reasons. First, new data communications requirements will greatly increase recurring costs unless a significant communications redesign occurs now. Second, the upcoming expiration of the Federal Telecommunications System 2000 (FTS 2000) and Leased Interfacility NAS Communications System (LINCS) transmission facilities and service contracts are likely to provide the timing window for significant improvements that the FAA must be prepared to take advantage of.[1] When completed, the NAS interfacility communications system will consist of several logical networks supported by a predominantly leased physical infrastructure. This logical and physical network architecture is essential to NAS modernization.

Logical Network

Design. The interfacility communications system will provide a set of software-defined networks that are logically partitioned to provide connectivity between facilities. Each logical partition will support independent virtual private networks (VPNs) that share common telecommunications resources. VPNs have most of the features of a private network while providing very reliable communications at a lower unit cost.

The interfacility communications system will consolidate networks in order to transport operational and administrative traffic over the same physical links. However, traffic will be logically partitioned into four (or more) virtual private networks—two for voice and two for data and video (see Figure 17-1). Other VPNs may be added to meet special needs (e.g., security requirements may require a separate VPN for Internet communications).

Common Physical Network Infrastructure.

The common physical network infrastructure is a shared physical networking environment that includes transmission, switching, multiplexing, and routing facilities. The common physical network infrastructure uses VPN technology to meet different administrative and operational performance requirements. It will also use a mix of transmission services and service providers to achieve the desired level of reliability and path diversity at the lowest cost.

The current physical communication networks consist of transmission systems (e.g., LINCS, radio communications link (RCL), and television microwave link (TML)); switching systems (e.g., National Airspace Data Interchange Network packet switch network (NADIN PSN)); and mul-

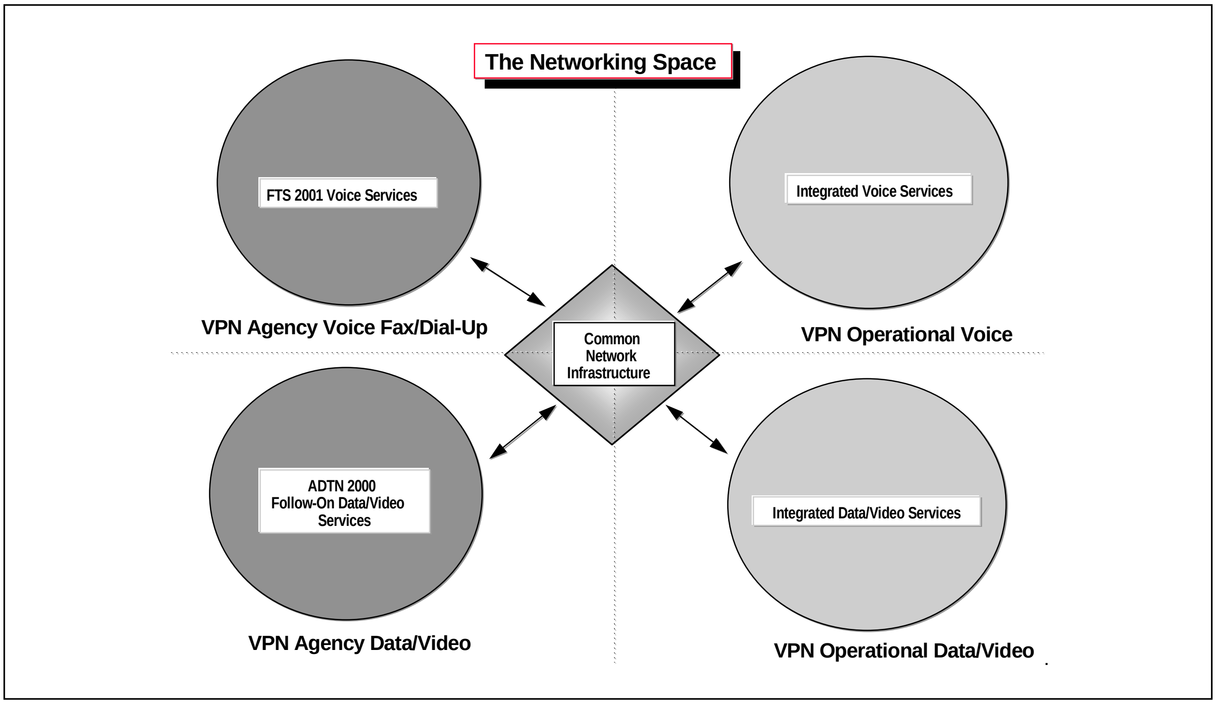

Figure 17-1. Logical Network Architecture

1. Note that the integrated communications system procurement does not include the following: air traffic control voice switches, the Alaskan NAS Interfacility Communications System (ANICS) ground infrastructure, digital airport telecommunications, administrative dial switches, or air-ground and mobile communications equipment and services.

tiplexing systems (e.g., data multiplexing network (DMN)). In the future, digital switches or routers at each ARTCC will replace existing multiplexer equipment. These various networks will be integrated by using a single transmission technology, such as asynchronous transfer mode.

Asynchronous transfer mode technology allows the replacement of dedicated physical trunks with virtual private trunks for operational traffic (currently the largest communications expenditure). It also provides a number of bandwidth-saving efficiencies, including channel release during moments of audible silence and compression of administrative voice (currently the largest traffic category). This technology can also provide multicasting, dynamic bandwidth allocation, quality of service guarantees, priority and preemption for critical and essential services, and survivability for operational-critical and essential services.

Each user application, whether operational or administrative, is assigned its own quality-of-service and priority. The highest priority would be used for critical operational traffic. Low-priority traffic would use the gaps between higher-priority traffic and any overflow capacity. Use of asynchronous transfer mode over satellite links, particularly over the FAA Telecommunications Satellite System (FAATSAT), could also provide better bandwidth utilization and better integration with terrestrial networks.

Frame-relay technology appears to be useful for data applications at sites where the total data requirement for network access is in the 64 Kbps to 1.544 Mbps range. This would require installing frame-relay access devices at small FAA sites. The frame-relay access devices can be connected to either a frame relay or an asynchronous transfer mode network.

Agency Voice VPN/Fax/Dial-Up. Voice services available through the Federal Telecommunications System (FTS 2000) contract will be replaced by an integrated telecommunications infrastructure that provides different classes of network connections and virtual circuits for all voice services needed to support FAA administrative functions. The classes of services implemented in the administrative voice VPN will depend on user needs. Those requiring high availability, for example, may receive dedicated bandwidth, while less critical voice services may receive a variable bit rate service that consumes less bandwidth and maintains low connect times.

Agency Data/Video VPN. VPN services provided by the integrated telecommunications infrastructure will be used for data networking, facsimile, dial-up, and video services needed for FAA business operations. Services will be assigned priorities according to business operations requirements. The integrated telecommunications infrastructure will also feature networking schemes to manage transmission control protocol/Internet protocol (TCP/IP)-based information and administrative data and video information.

Operations Voice VPN. VPN services provided by the integrated telecommunications infrastructure will be used for voice communications for NAS operations. This VPN will have the highest priority service in order to meet NAS voice operational requirements. Operational voice services requiring extremely high availability may be configured with a permanent virtual circuit class of service that provides dedicated connectivity. The operations voice VPN will include major air traffic facilities, such as air route traffic control centers (ARTCCs), terminal radar approach control (TRACON) facilities, and airport traffic control towers (ATCTs).

Operations Data/Video VPN. VPN data and video services available in the integrated telecommunications infrastructure will provide the data networking and video capability needed for NAS operations. The logical network design employed within the VPN framework will satisfy operational requirements for critical data and video services by using the appropriate class of service connections.

Physical Network Design

External Interfaces. Gateways and routers will provide external communications interfaces for the Department of Defense (DOD), aviation industry users, service providers, and international agencies. Access gateways or routers will be used between the appropriate FAA VPN and the airline operations center network (AOCNet). Aviation industry access will facilitate traffic flow management (TFM), collaborative decisionmaking (CDM), and other similar initiatives.

Network Management and Operation. The integrated telecommunications infrastructure will interface with the operations control centers and exchange both real-time and non-real-time information. The telecommunications infrastructure will provide the following network management services:

- Real-time information exchange
  - – User help desk for service restoration and coordination
  - – Network performance statistics
  - – Hardware and software configuration
  - – Remote equipment status
- Electronic security
- Non-real-time information sharing
  - – Network statistics
  - – Network planning
  - – Billing and accounting data
  - – Port utilization data.

17.1.1.1 Interfacility Communications System Evolution—Step 1 (Current–1998)

It is estimated that the FAA employs more than 25,000 interfacility point-to-point and multipoint circuits for air traffic services—of which roughly 60 percent are used for voice and 40 percent for data. FAA voice and data communications are often combined (multiplexed) over backbone transmission systems, although they are generally handled separately on the access networks.[2] Most voice and data circuits are leased on a monthly basis from communications service providers. Of the approximately $300M spent by the FAA on telecommunications in FY95, nearly 60 percent was for recurring circuit costs.

Today’s interfacility operational voice communications are based on voice switches with analog voice output. Since the vast majority of interfacility voice trunks are digital (provided by LINCS), the analog voice signal must be digitized before it is transmitted. Operational voice circuits are usually configured as dedicated point-to-point and multipoint circuits and are used only a few minutes per hour.

Voice switches in the current system are not capable of switching calls through to another switch (tandem switching) and typically do not provide supervisory signaling. In cases where supervisory signaling is provided, it is typically provided inband, which forces switches to rely on dedicated point-to-point or multipoint circuits for connectivity to other switches. This results in a highly inefficient use of communications bandwidth, given the NAS voice traffic loading profile.

Today’s interfacility data communications provide a variety of circuits and connection types between FAA sites. At the transmission level, RCL, TML, and low-density radio communications link (LDRCL) use analog and digital microwave circuits; FTS 2000 and LINCS use copper and optical fiber circuits; and Alaska NAS Interfacility Communications System (ANICS) and FAATSAT use satellite circuits. The FTS 2000 contract expired in 1998 and will be replaced by the FTS 2001 contract.

The data switching environment largely consists of separate, lightly loaded, low-bandwidth networks. The technologies used include a 1960’s message switch network (i.e., NADIN message switch network (MSN)), several 1970’s asynchronous systems used for weather data collection and distribution, a 1970’s X.25 packet switch network (i.e., NADIN PSN), which is currently being upgraded to modern frame-relay capabilities, and a DMN that uses analog transmission circuits. Each network is administered, operated, and maintained separately and is generally unable to back up the other networks.

One way the FAA is improving network efficiency is through the use of bandwidth management systems that are capable of switching between independent transmission networks (e.g., RCL, LINCS, FAATSAT). Bandwidth management provides the ability to multiplex voice and data over higher-capacity trunks when it is cost-effective and simplifies transition to other service providers.

2. Low-speed data circuits are routinely combined on the FAA’s DMN to achieve cost savings on interfacility circuits.

Except for high-end video conferencing, all agency data requirements are met by the Administrative Data Transmission Network 2000 (ADTN 2000). ADTN 2000 employs multiprotocol routers in conjunction with a frame-relay core to carry monthly traffic in excess of 300 gigabytes with an average delay under 200 milliseconds and availability of 0.999.

17.1.1.2 Interfacility Communications System Evolution—Step 2 (1999–2008)

To meet FAA communications growth in the next century, the interfacility communications system consolidates most of the transmission systems and voice and data networks within a single integrated communications infrastructure that offers integrated voice, data, and video services across the NAS. The new telecommunications infrastructure will provide improved performance at a lower unit cost.

The NAS ground-ground operations voice network will transition from a point-to-point network using dedicated trunks to a switched network that provides bandwidth on demand. The FAA will migrate from analog switch interfaces that use in-band signaling to digital interfaces and out-of-band signaling. Air traffic control (ATC) switches that currently use digital technology will have analog interfaces replaced with digital interfaces. Switches based on analog technology such as the small tower voice switch (STVS) will be provided, if cost-effective, with ear and mouth (E&M) signaling and connected to a channel bank or a network termination device in order to interface with the digital network. Future voice switches will not require legacy interfaces.

Data communications to international air traffic services (ATS) facilities will evolve from the existing aeronautical fixed telecommunications network (AFTN) infrastructure to an ATN-based infrastructure. Most of the FAA's telecommunications systems (RCL, LINCS, FTS 2001, NADIN MSN, NADIN PSN, and the bandwidth manager) will be incorporated in the integrated telecommunications infrastructure.[3]

ANICS, FAATSAT, and the DMN will be integrated next. The LDRCL, however, will remain in service as a separate FAA-owned transmission system. Figure 17-2 provides an overview of the NAS interfacility environment as it will appear in this step. Edge devices (e.g., the edge/access device shown in Figure 17-2) will physically interconnect the integrated backbone network with legacy local area networks (LANs) and switches. These edge devices will initially route internetwork packets, but may evolve to provide both routing and switching functions. NADIN MSN

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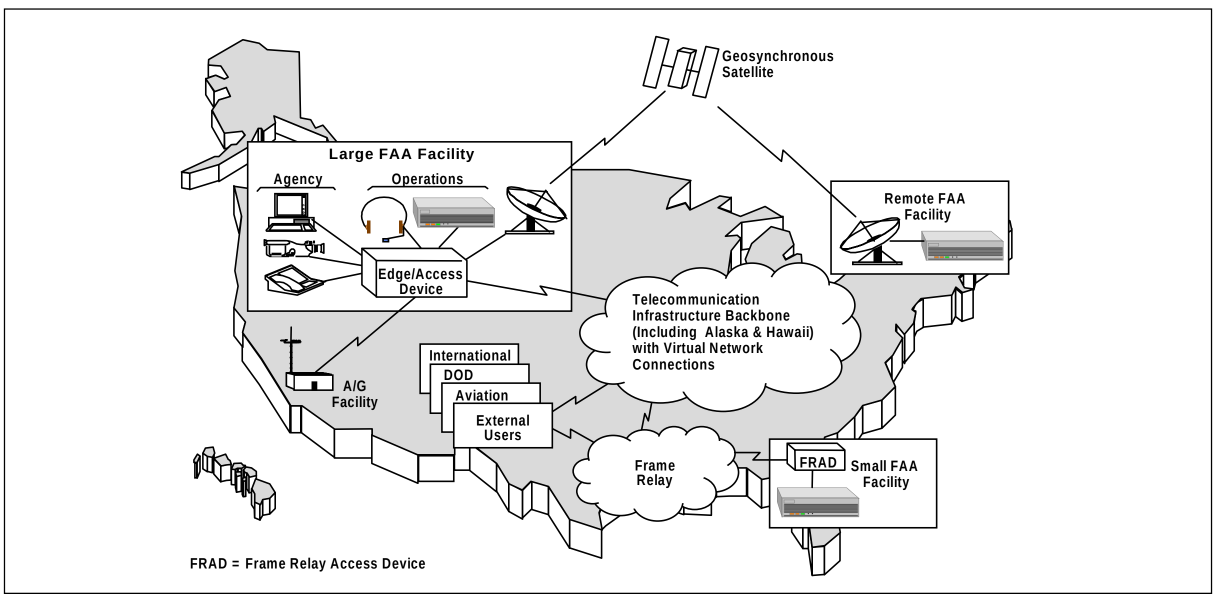

Figure 17-2. Interfacility Architecture in 2008

3. Mission Need Statement (MNS) *FAA Telecommunications Infrastructure* was approved in May 1998.

will be rehosted and will connect directly to an edge device.

17.1.1.3 Interfacility Communications System Evolution—Step 3 (2009–2015)

The interfacility communications system looks the same as the previous step, but undergoes technology refreshment, speed increases on access trunks, and a new generation of NAS voice switches with modern network interfaces is introduced. In addition to these qualitative improvements, cell-based multimedia networks are expected to become available at competitive prices from several vendors. In hard-to-service locations where access costs do not support diversity today, the FAA may employ switched access to low earth-orbiting (LEO) and medium earth-orbiting (MEO) satellite-based networks. Many LDRCLs will be phased out by competitively priced services available from communications carriers. Where such service is not available, LDRCL will remain.

17.1.1.4 Interfacility Communications Schedule

Transition of interfacility communications begins with replacement of the General Services Administration (GSA) FTS 2001 contract. This will be followed by implementing the integrated telecommunications infrastructure, which includes LINCS replacement. LINCS circuit cutover and network conversion schedules will be based on a 2-year transition period. These cutovers will be as expeditious as possible to reduce the time needed to support two networks. For safety, the old network service will be maintained after cutover until the new service has proven itself in a live environment. The communications transition schedule shown in Figure 17-3 assumes a multiyear conversion period that minimizes the impact on FAA staff and ensures a sufficient period of dual operation.

17.1.2 Intrafacility Communications System Evolution

Intrafacility data communications evolution will follow an approach similar to that used in the current administrative system (i.e., widespread use of commercial off-the-shelf (COTS) client-servers and LAN/IP-based networks connecting operational sites). This evolution is already in progress in a large number of major programs, (e.g., the display system replacement (DSR), Standard Terminal Automation Replacement System (STARS), weather and radar processor

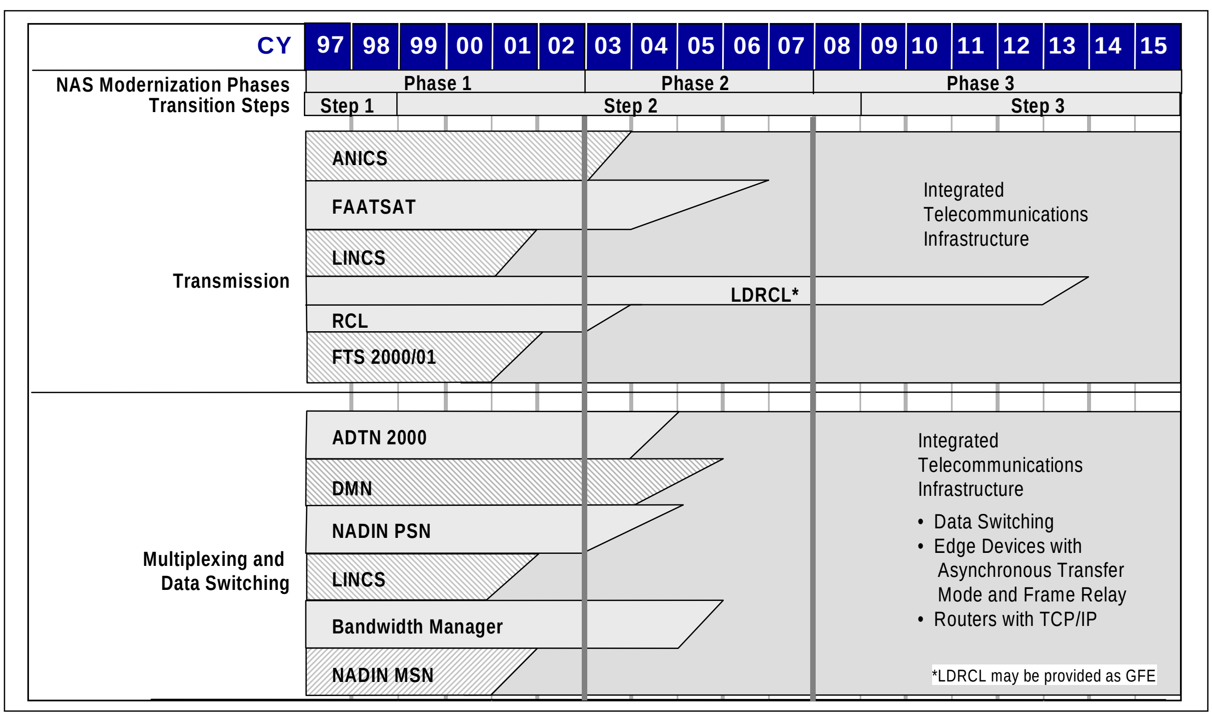

Figure 17-3. Interfacility Communications Transition

(WARP), center TRACON automation system (CTAS), enhanced traffic management system (ETMS), Operational and Supportability Implementation System (OASIS), and host interface device (HID)/NAS LAN). Like the interfacility network that connects operational sites, a number of special features are needed at ATC sites to ensure high availability (e.g., physical, electrical, and power diversities). The basic system components (i.e., LANs, routers, switches, and security access servers) are common to both the interfacility and intrafacility environments and will also provide support for low-speed video transmission.

Intrafacility ATC voice communications will continue to be provided by FAA-owned switches for the foreseeable future.

17.1.2.1 Intrafacility Communications System Evolution—Step 1 (Current–1999)

Today's intrafacility system carries all voice and data communications exchanges within facilities and provides services tailored to the largest ARTCCs and TRACONS as well as the smallest towers.

There are approximately 480 air traffic services voice switches consisting of eight different models from three vendors. These voice switches come in various sizes and configurations and include the STVS, rapid deployment voice switch (RDVS), integrated communications switching system (ICSS), traffic management voice switch, voice switching and control system (VSCS), emergency voice communications system (EVCS), and the soon-to-be-deployed enhanced terminal voice switch (ETVS). The intrafacility intercom services they provide are fundamentally the same in each.

Virtually all intrafacility data communications occur at speeds of 64 Kbps or slower. Although planned, there are no general-purpose LANs in the air traffic data environment today. The result is that each local system must be directly connected to another system it shares information with. The addition of new automation software and hardware combined with the large number of protocols and interfaces required thus results in a complex and hard-to-maintain system. The physical accumulation of wiring in many sites also poses severe restraints on access and upgrades.

The administrative data environment is supported by the Office Automation Technology Services (OATS) contract, which provides modern personal computers and Ethernet LANs for all of its office facilities.

17.1.2.2 Intrafacility Communications System Evolution—Step 2 (2000–2004)

Existing data communications (such as weather) will be transitioned to IP-based communications protocols. Surveillance data will be converted into a common format, the All Purpose Structural EUROCONTROL Radar Information Exchange (ASTERIX), for transmission of data from radars to ARTCCs and TRACONs. IP multicasting capabilities will route data collected for one application (e.g., surveillance, WARP, and integrated terminal weather system (ITWS)) to other applications (e.g., those for air traffic management).

Some agency LANs and facility cabling may be incorporated in the integrated communications infrastructure, leaving existing LANs (i.e., HID, STARS) in place. Figure 17-4 provides an overview of the NAS intrafacility environment in this step.

Voice switches in this step will continue to provide their current intrafacility functions.

17.1.2.3 Intrafacility Communications System Evolution—Step 3 (2005–2015)

Edge switches will be deployed, intrafacility communications speeds will increase, and protocol standardization will be established in the LAN domain. Deployment of fewer, more versatile protocol stacks will reduce maintenance support and troubleshooting and improve interfacility and application-to-application communications. The telephony environment is expected to be integrated via a cell-based protocol running over the LAN; this opens the possibility of higher levels of integration (i.e., data, video, and voice). Currently, gigabit LANs are being developed by industry, and standards are being redefined.

The FAA will acquire a new generation of ATC voice switches to replace its aging and hard-to-maintain inventory. The next generation of digital switches will likely come in several sizes and will meet the requirements of the future ATC voice network. Voice switches will provide the in-

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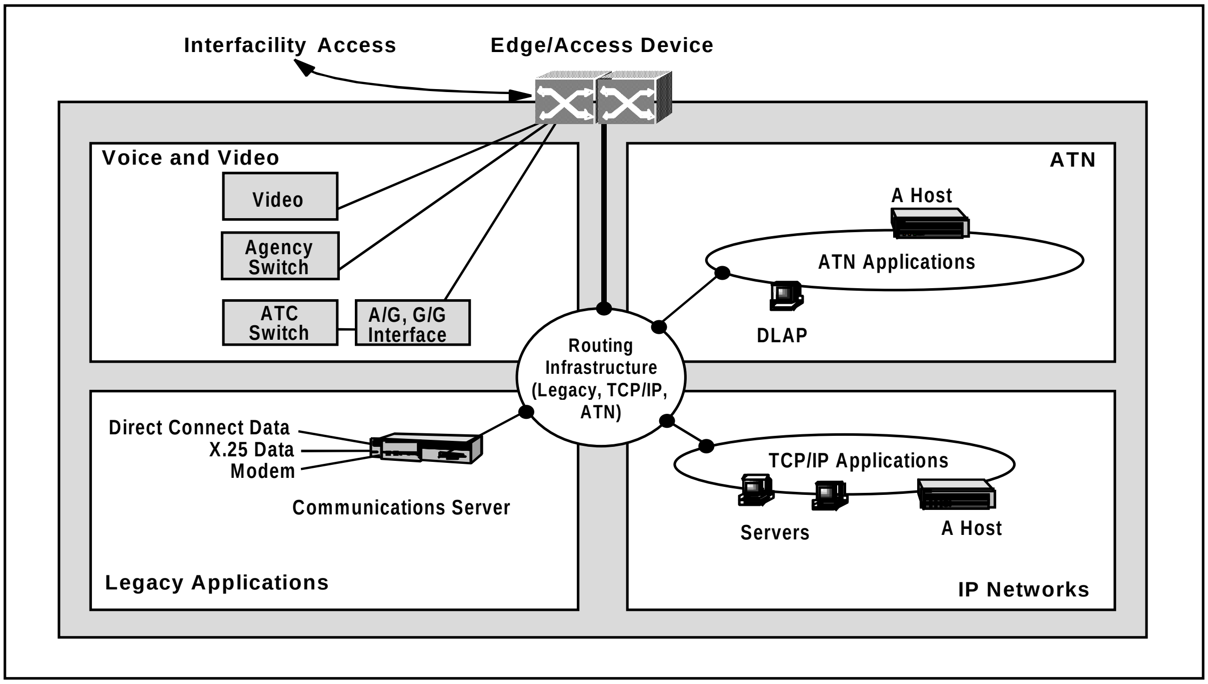

Figure 17-4. Intrafacility Architecture in 2004

trafacility functions required to support the new CONOPS.

Because of the high cost of customized switches, a number of smaller FAA facilities, both operational and administrative, might be economically served by off-site switching. Switches will be replaced as follows:

- ICSS, RDVS, and STVS will be replaced by the voice switch replacement system.
- ETVS will be gradually replaced by the voice switch replacement system.
- VSCS will be replaced after 10 years of service.

Figure 17-5 provides an overview of the NAS intrafacility environment in this step.

17.1.2.4 Intrafacility Communications Schedule

The transition to this new intrafacility environment is already in progress as evidenced by the deployment of the American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) 802.n-compliant HID NAS/LAN and the prototyping of various new IP/LAN-based applications. Figure 17-6 shows the intrafacility communications transition schedule. Under the current acquisition system, application development projects provide their own computer hardware and much of the required communications equipment. This has led to an array of communication equipment types, compounding facility infrastructure and maintenance problems. The new approach stipulates use of COTS equipment (clients, servers, LAN switches, network interface cards (NICs), routers, fax machines, etc.), and, in particular, protocol converters. The integrated telecommunications infrastructure will offer LAN equipment along with site installation and wiring assistance. EVCS will be decommissioned and incorporated into the follow-on integrated communications infrastructure.

17.1.3 Mobile Communications System

The mobile communications system consists of air-ground and ground-ground components. The air-ground component provides communications paths between controllers and pilots in both domestic and oceanic airspace. The ground-ground component (see Section 17.1.3.2) consists mainly of portable radios used by maintenance personnel.

17.1.3.1 Air-Ground Mobile Communications

Current NAS air-ground communications are provided by an analog system using HF, very high frequency (VHF), ultra high frequency (UHF), and satellite communications (SATCOM) radios.

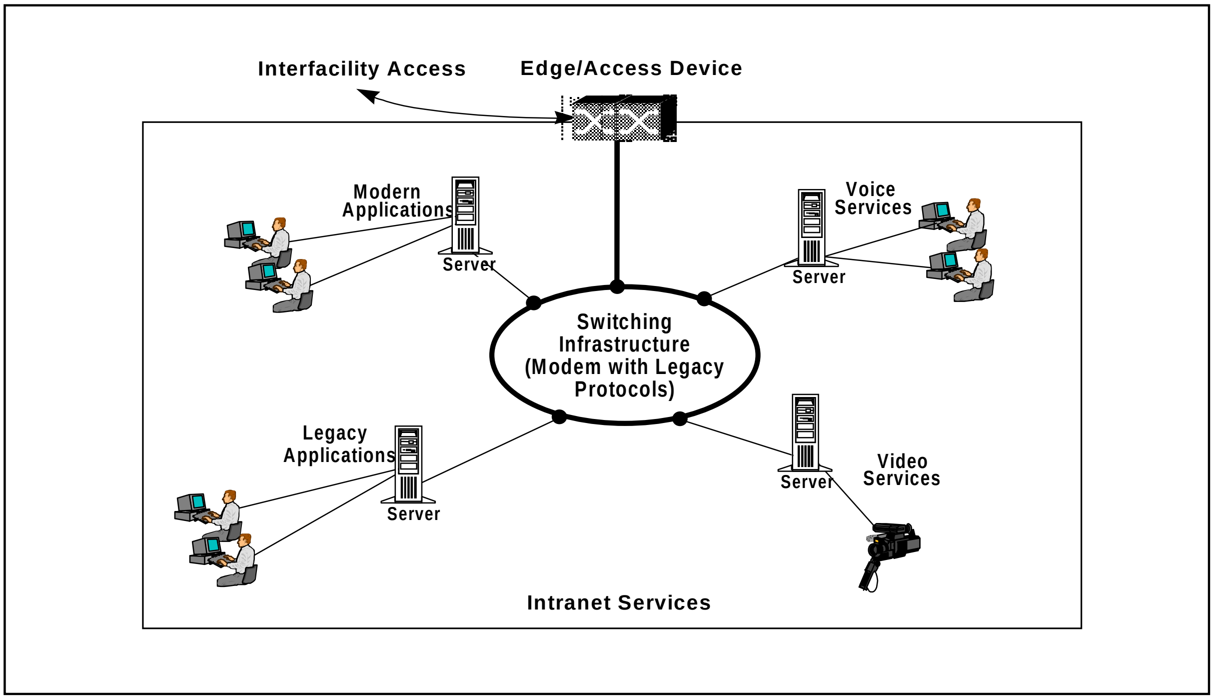

Figure 17-5. Intrafacility Architecture in 2010

Only limited data transmission capability exists in domestic airspace (predeparture clearance and digital air traffic information service) and in oceanic airspace (waypoint position reports via Future Air Navigation System (FANS)-1/A). As the NAS is modernized, however, this balance will shift toward ATN-compliant data communications and attention must be focused on the radios,

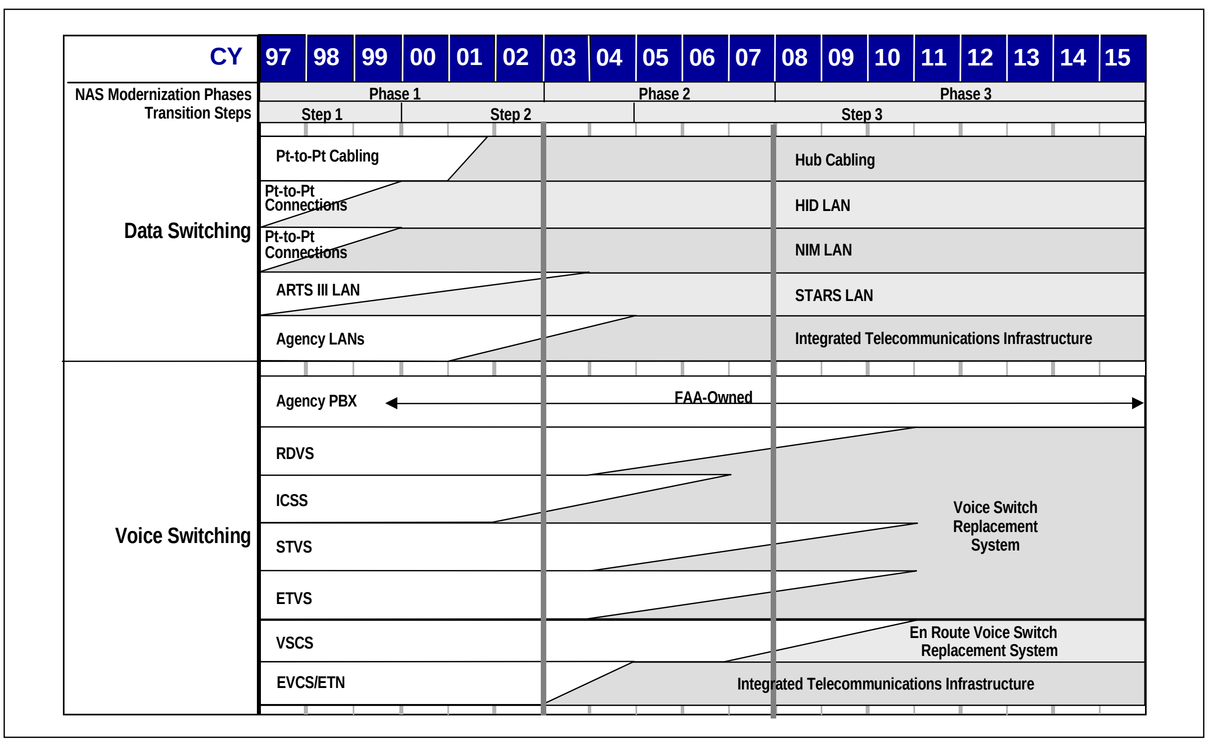

Figure 17-6. Intrafacility Communications Transition

processors, and applications needed to support data transmission. A discussion of data link systems and services is found in Section 17.1.4. The various applications are covered in Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface.

In domestic airspace, voice communications for ATC operations are provided by VHF radios operating in the aeronautical mobile communications band (118-137 MHz) and UHF radios operating from 225 to 400 MHz. (UHF is used to communicate with military aircraft.) A 4-percent annual growth in VHF channel requirements over the past 20 years has used up most of the available channels. As a result, current requests for resectorization and new services are being denied in many cases, and certain services, such as weather advisories, are being limited in high-traffic density areas, such as Chicago.

For technical and economic reasons, a joint FAA and aviation industry decision was made to implement very high frequency digital link (VDL) Mode-3 domestically to solve these problems. As a result, the next-generation air-ground communications system (NEXCOM) will be an integrated voice and data system that uses the currently assigned 25 KHz VHF spectrum. This differs from the interim solution planned for European airspace, which subdivides the current 25 KHz spacing into 8.33 KHz channels.

In oceanic airspace, air traffic voice services are provided over HF radio using a communications service provider. The only currently available means by which to conduct oceanic data communications is SATCOM, but high frequency data link (HFDL) service is expected to provide a reliable, low-cost alternative.

Voice communications via HF radio are significantly influenced by atmospheric and solar disturbances. SATCOM voice communications are a reliable alternative but have high installation and transmission costs. Consequently, oceanic communications will evolve from relatively slow HF voice message contacts to short duration SATCOM data messages complemented by HFDL and HF voice. Voice will always be required for nonroutine oceanic communications. Satellite voice—currently being explored for emergency communications—may eventually play a larger role in other communications services.

17.1.3.1.1 Air-Ground Mobile Communications System Evolution—Step 1 (Current–1998)

At the center of air traffic communications is the VHF/UHF air-ground mobile voice communications system. This aging analog system has approximately 50,000 ground-based radios at nearly 4,000 sites. The radios operate in a simple push-to-talk mode, with the same frequency being used for both controller-to-pilot and pilot-to-controller transmissions. There is growing concern over the present VHF communications system because of increasing channel assignment requirements, low channel utilization, voice congestion on high-activity channels, moderate service availability, high failure rates (with older radios), susceptibility to channel blockage (“stuck mike” and “step-on”), increasing radio frequency interference, and lack of security.

In addition to VHF air-ground communications, other currently deployed systems include: Skylinks, which uses HF and satellite communications for oceanic voice and data; recovery communications used by site service technicians; tower data link services (TDLS); and the meteorological data collection and reporting system (MDCRS).

17.1.3.1.2 Air-Ground Mobile Communications System Evolution—Step 2 (1999–2005)

A new service provider network, VDL-2, will be used initially by one ARTCC to provide limited ATC data link service for en route airspace.

The existing domestic air-ground system (composed of VHF radios, backup emergency communications (BUECs), and radio control equipment (RCE)) will continue to provide voice communications during transition to the NEXCOM system. NEXCOM radios will be installed first in all high-altitude and super-high-altitude en route sectors. Initially, all multimode NEXCOM radios will operate in analog mode (i.e., emulate the current radios). En route sectors above Flight Level 240, however, will begin transition to digital voice mode operation near the end of this time period.

Oceanic communications will migrate from primary dependence on service provider HF voice to data link service via satellite and HFDL. HF voice and SATCOM voice will remain available for backup.

Figure 17-7 depicts the mobile communications system (including air-ground communications) as it will appear in this time period.

17.1.3.1.3 Air-Ground Mobile Communications System Evolution—Step 3 (2006–2010)

The ground network infrastructure needed to support data link services over NEXCOM, as appropriate, will be deployed for operation in the ARTCCs.

Most oceanic traffic will complete the transition to HFDL and satellite ATN-compliant data link communications in this time period. A dual protocol stack is planned to maintain compatibility with FANS-1/A-equipped aircraft in the ATN environment.

17.1.3.1.4 Air-Ground Mobile Communications System Evolution—Step 4 (2011–2015)

Selected high-density terminal airspace and the associated low en route sectors will transition to digital NEXCOM service in this period. Civilian aircraft flying instrument flight rules (IFR) in these areas will require NEXCOM radios. UHF radio service will continue until the DOD equips military aircraft with NEXCOM radios. As users equip with the avionics needed for data communications, data services will migrate from VDL Mode-2 to NEXCOM, and new data link services will be provided directly by the FAA. NEXCOM radios operating in analog voice mode will continue to replace legacy radios in order to sustain the overall air-ground system.

Service provider networks are expected to accommodate new data communications applications in domestic and oceanic airspace. For oceanic communications, satellites will be used increasingly for new applications as the cost of satellite services declines. A transition to domestic air-ground satellite service is dependent on performance, equipage, and competitive pricing for service.

Figure 17-8 depicts an overview of the mobile communications system as it will appear in this time period.

17.1.3.2 Ground-Ground Mobile Communications

Agency ground-ground mobile communications are modest but widespread. The FAA uses a large number of pagers, portable telephones, and modem-equipped laptop computers. The latter are

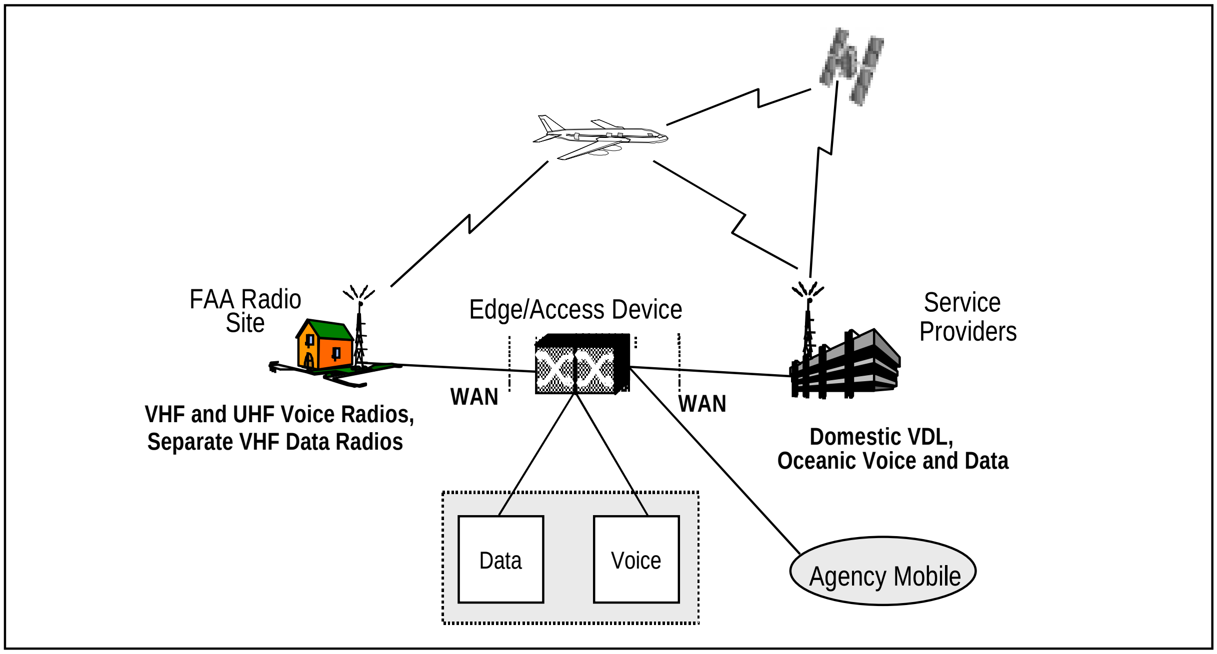

Figure 17-7. Mobile Communications Architecture in 2005

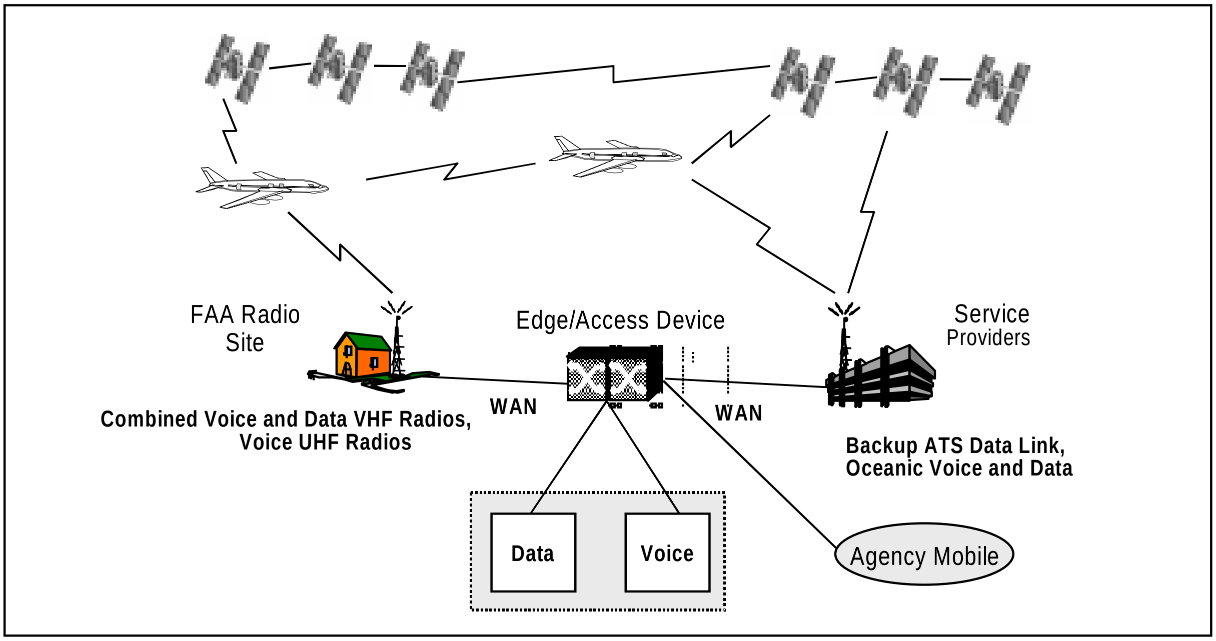

Figure 17-8. Mobile Communications Architecture in 2015

used to access data bases on departmental servers and to send and retrieve e-mail.

The present method of procuring mobile communications for maintenance and administrative use (e.g., pagers and mobile radios) is through the FTS 2000 contract. This same method will be used in the follow-on contract, FTS 2001.

17.1.3.3 Mobile Communications Schedule

The major events occurring during the mobile communications transition are shown in Figure 17-9.

17.1.4 Data Link Service

The purpose of data link applications is to facilitate exchange of ATC weather, flight service, and aeronautical information between aircraft and ground systems. Data link is expected to reduce congestion on voice channels; reduce misunderstanding of instructions and information; reduce the need for transcribing messages by air crews; reduce the workload of FAA ground personnel, such as air traffic controllers and flight service specialists; and facilitate CDM. The aviation user community—through forums such as RTCA Task Force 3 and the Free Flight Select Committee—has stated a firm need for data link in order to achieve operational benefits.

Data link includes the computer-human interface (CHI) for pilots and controllers, applications software in cockpit avionics and ground automation systems, the data link applications processor, and the communications infrastructure (air-ground, airborne, and ground communication systems). The previous section, 17.1.3, describes the air-ground transmission system that will be used for data link. This section, along with the automation sections, describes the applications software. See Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing; Section 20, Traffic Flow Management; Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; Section 24, Tower and Airport Surface; Section 25, Flight Services; and Section 26, Aviation Weather.

A number of data link applications will use ATN to provide global, seamless, secure, and error-free communications between air- and ground-based systems. ATN will use multiple subnetworks (i.e., VDL, HFDL, and SATCOM) to provide this service.

17.1.4.1 Data Link Service Description

Data link services will be implemented in stages to facilitate phased delivery of user benefits. The stages also allow familiarization with the new technology and orderly integration with the NAS

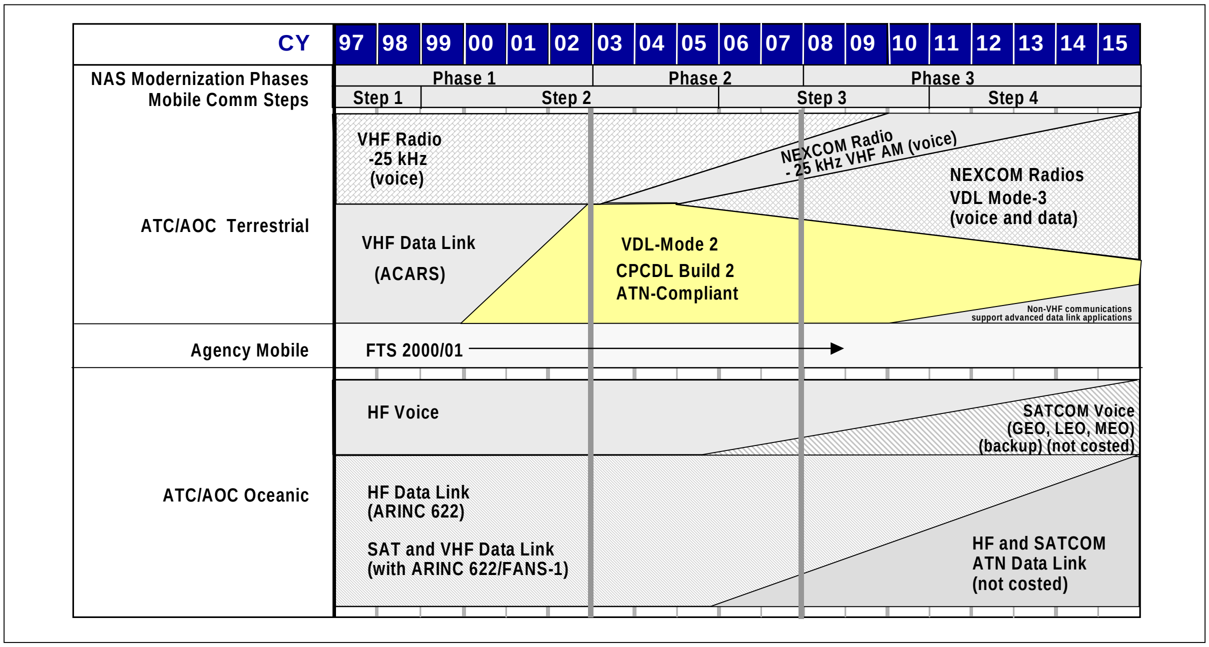

Figure 17-9. Mobile Communications Transition

telecommunications and automation infrastructures. Initial services will provide a foundation for more advanced services and will evolve from computer-to-human information transfer to include computer-to-computer information transfer.

Data link will provide three major evolutionary capabilities:

- Services that support communications between pilots and controllers
- Ground-based services that provide relevant information to pilots
- Decision support services that support coordination among flight decks, airline operations centers (AOCs), and air traffic management services for efficient flight management.

The data link section discusses services in the following order:

- Controller-Pilot Communications and Air Traffic Services:
  - – Tower Data Link Services (TDLS)
  - – Data Delivery of Taxi Clearance (DDTC)
  - – Controller-Pilot Data Link Communications (CPDLC)
  - – Oceanic Two-Way Data Link Communications (TWDL) Services
- Flight Information Services:
  - – Flight Information Service (FIS)
  - – Meteorological Data Collection and Reporting System (MDCRS)
  - – Terminal Weather Information for Pilots (TWIP)
  - – Traffic Information Service (TIS)
- Decision Support System (DSS) Services.

17.1.4.1.1 Controller-Pilot Communications and Air Traffic Service

CPDLC is a means to provide ATS data services, which are currently voice-oriented, and to transition some of these services to data link. The earliest stage of data link is currently in operation and supports communications such as predeparture clearances (PDCs) and digital automated terminal information services (D-ATIS). A data delivery of taxi clearance service is being tested as a prototype capability at the Detroit Tower. In oceanic airspace, FANS-1/A-equipped aircraft use data link service via SATCOM to exchange all types of ATC messages, including automatic dependent surveillance addressed (ADS-A).

Tower Data Link Service. The TDLS system automates tower-generated information for transmission to aircraft via data link. TDLS interfaces with sources of local weather data and flight data and provides PDC and D-ATIS. PDC helps tower clearance delivery specialists compose and deliver departure clearances. The clearances are then transmitted in text form via the Aircraft Communication and Reporting System (ACARS) to an ACARS-equipped aircraft for review and acknowledgment by the flight crew. The D-ATIS application also enables controllers to formulate D-ATIS text messages for delivery. The ATIS text messages are then delivered to flight crews via ACARS data link. An ATIS automatic voice-generation function produces spoken broadcasts using a synthesized voice to read the ATIS message.

Data Delivery of Taxi Clearance. DDTC is being implemented as a prototype capability at the Detroit Tower for operational assessment by the FAA. DDTC, like PDC, reduces both the delay in communicating the clearance information as well as any inaccuracies inherent in voice communications. The DDTC service will also use ACARS and, based on results, may be expanded to other TDLS locations.

Controller-Pilot Data Link Communication. CPDLC will be implemented first in the en route environment in a four-step process to introduce early benefits to NAS users while minimizing technical and procedural risks during development of the ATN-compliant system. Each of these steps is associated with specific automation software development and implementation activities (e.g., host computer software releases, DSR implementation and upgrades, and data link applications processor (DLAP) implementation).

Oceanic Two-Way Data Link Service. FANS-1/A avionics enables Boeing and Airbus aircraft to conduct TWDL. FANS-1/A-equipped aircraft will have automatic dependent surveillance (ADS) capability in FAA-controlled Pacific Ocean airspace. Oceanic data link services will evolve to ICAO-ATN-compliant communication services and applications over an extended transition period of accommodation for both FANS-1/A- and ATN-equipped users.

17.1.4.1.2 Flight Information Services

Flight Information Service. FIS will be provided to the cockpit by data link in the future. FIS information is defined as noncontrol advisory information needed by pilots to operate more safely and efficiently in both domestic and international airspace. FIS includes information necessary for continued safe flight and for flight planning, whether in the air or on the ground.

The rationale for providing FIS to the cockpit via data link is to improve safety, increase NAS utility, efficiency, and capacity and reduce costs to the user and the FAA. FIS is intended to complement, not replace, existing voice communications. Initial FIS products for delivery to the cockpit include information on NAS status (e.g., notices to airmen (NOTAMs) and special use airspace (SUA)) and meteorological information in text and graphic formats.

FIS depends on both public and private enterprise to provide affordable FIS products. To ensure services are developed and provided to the cockpit, the FAA will use private sector FIS wherever possible to bring services and products to the marketplace quickly and efficiently. The FAA will make NAS status and existing weather data available to private data link service providers for the development of FIS products. Commercial providers may make basic FIS products available, at no cost to the government or the user, and may make “value-added” products available for a fee. Such products are likely to include graphical/textual weather dissemination, first as a broadcast service, then as request-reply. Enhanced FIS, the final system, is likely to offer a mix of both government- and private sector-provided services.

Meteorological Data Collection and Reporting System. A number of today’s aircraft measure wind, temperature, humidity, and turbulence information in-flight and automatically relay the information to a commercial service provider. The service provider collects and reformats the information into MDCRS format and forwards it to the National Weather Service (NWS). The NWS uses this information and weather data from other sources to generate gridded weather forecasts. The forecasts are distributed to airlines and the FAA to help plan flight operations. The NWS gridded weather forecasts generated based on MDCRS will also be provided to WARP for use by meteorologists and to be forwarded to other automation systems and tools, such as the User Request Evaluation Tool (URET). ITWS will combine MDCRS with other terminal area weather information to create a high temporal, high horizontal resolution (5 minute/2 km) terminal area wind forecast.

Terminal Weather Information for Pilots. TWIP uses information from the terminal Doppler weather radar (TDWR) to provide near real-time aviation-tailored airport windshear and micro-burst information to pilots in the form of text and character graphic messages over ACARS. The future transition of TWIP to ITWS will improve the accuracy of weather information to the cockpit. TWIP functionality will be incorporated into the airport surveillance radar-weather system processor (ASR-WSP) system, thereby extending windshear coverage. By expanding the choices of delivery mechanisms, it may be possible to extend this capability to a broader community of users.

Traffic Information Service. The TIS application is being fielded currently at 119 sites nationwide. Using the Mode-S data link, a TIS ground processor uplinks surveillance information generated by a Mode-S sensor to properly equipped aircraft. The aircraft TIS processor receives the data and displays the data on the TIS display, providing increased situational awareness and an enhanced "see-and-avoid" capability for pilots.

17.1.4.1.3 Decision Support System Services

The most advanced set of capabilities will come from the interaction of air and ground DSSs. These expanded data link services are required to integrate flight deck systems, such as flight management systems (FMSs) with advanced ATM capabilities. The automated downlink of information, such as aircraft position, velocity, intent, and performance data from flight management systems to ground-based DSSs, will improve trajectory prediction and increase the accuracy of these systems.

17.1.4.2 Data Link Service Evolution (2000–2008 and Beyond)

Initial data link services only involve information to aircraft and require no reply from the flight deck. The next stage of evolution adds controller-pilot dialogue capability to communicate strategic and tactical air traffic services messages that are currently conveyed by voice. This will be augmented with request-reply functionality, which is initiated by the flight deck. In this case, a ground-based processor receives a downlinked request from the flight deck, compiles the requested information, and uplinks it to the aircraft for display. Next, data link will facilitate an automated downlink of weather and aircraft state-and-intent information to improve the prediction capabilities of decision support and weather systems. Finally, data link will facilitate a more extensive use of user-preferred trajectories through the negotiation of conflict-free trajectories between the flight deck and ATC service providers.

Data Link Architecture Evolution

Step 1 (1999-2002). CPDLC Build 1 will introduce an initial ATN-compliant CPDLC data link capability at one key site—the Miami ARTCC—for four selected messages over the VDL Mode-2 network. Four selected message types are potential candidates for this: transfer of communications (TOC), initial contact (IC), altimeter setting message (ASM), and predefined messages (PDM). The TOC will be the first message type to be tested. This leverages planned avionics upgrades by the airlines to equip with VDL Mode-2 for AOC communications and to participate in ATN data link trials in Europe. This approach should ensure a reasonable population of suitably equipped aircraft for initial operation and evaluation. This key site evaluation will determine operational utility and whether users benefits are sufficient to warrant further development. It will mitigate risks by deploying an operational tool to evaluate system performance, training procedures, and human factors requirements and solutions.

A multisector oceanic data link (ODL) that uses satellite communications is being installed to provide a reliable data communications link between pilots and controllers for FANS-1/A-equipped aircraft. This data communications consists of internationally standardized CPDLC messages for routine air traffic control and free text messages (see Section 22, Oceanic and Offshore).

Initial flight information services, such as weather to the cockpit, are currently available via a service provider. TIS, via Mode-S data link, are being fielded at selected sites nationwide.

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Step 2 (2002-2004). CPDLC Build 1A expands the message set from 4 to 18 operational messages, including pilot-initiated downlink messages. This build will continue to use VDL Mode-2 technology. Minor changes to the en route automation system (i.e., Host/oceanic computer system replacement (HOCSR)) and DLAP are required, but no upgrades are needed for the avionics. Expansion will take place center by center to ensure an orderly transition to nationwide implementation. Throughout this process, the results of the U.S and EUROCONTROL projects will be used to refine the cockpit and controller human factors and refine the message set for CPDLC Build 2; this will provide a set of messages with the most value to pilots and controllers.

During this time frame, ADS-A will provide surveillance of intercontinental flights in oceanic airspace through satellite data link. ADS-A will allow automated position reports and intent information to be periodically sent from the aircraft FMS to ground controllers via data link. This represents a significant improvement over manual voice reporting. The ground controller establishes the frequency of reports with the FMS and sets the event threshold for conformance monitoring. The FMS automatically transmits any deviations from assigned altitude or course. Additional information is included in Section 22, Oceanic and Offshore.

Step 3 (2004-2006). CPDLC Build 2 via VDL Mode-2 expands the message set from 18 to more than 100 operational messages. DSR will require changes to make the CHI suitable for the expanded message set. En route automation changes will also be required.

Step 4 (2007–2015). CPDLC Build 2 will transition from VDL Mode-2 to the FAA-owned NEXCOM air-ground communication network that uses VDL Mode-3 technology. VDL Mode-2 will continue to be available via a service provider for AOC use. Later in the step, CPDLC Build 3 will be implemented over the NEXCOM air-ground communications network. Build 3 will provide the full ICAO-ATN-compliant message set for both the en route and the high-density terminal domains. Compared to VDL Mode-2, NEXCOM will have greater capacity and will provide message prioritization that meets operational requirements associated with the full ATN-compliant message set. NEXCOM will also satisfy communications performance requirements needed for decision support services.

NAS-wide data link services will be available from a combination of service providers and the FAA. It will include the full CPDLC message set and expanded FIS and TIS.

17.2 Summary of Capabilities

Today's air-ground radio system was designed for analog voice but has been adapted to provide limited data exchange capability. Currently, predeparture clearances and D-ATIS are being provided at 57 airports using ACARS, a VHF service provider system operating at 2400 bps. The meteorological data collection and reporting system services also use ACARS, which transmits in-flight weather observations to the NWS. Taxi clearances over ACARS were demonstrated in 1997, and a nationwide implementation of this system is planned.

Selected non-time-critical CPDLC messages for transfer of control using ATN-compliant protocols over VDL-2 will be implemented first at a key site. Coverage will be expanded nationwide using a larger message set. NEXCOM will be introduced in three steps beginning with digital voice for en route communications, followed by en route data link communications and then expanding NEXCOM service to the busiest terminal areas. All aircraft with the exception of military aircraft will require NEXCOM radios to operate in selected airspace at that time.

FANS-1/A TWDL will become operational in 1998. HF voice, HFDL, and satellite communications will all be available in the oceanic environment for many years.

Figure 17-10 shows data link evolution beginning with existing operational and prototype services.

17.3 Transition

The key communications transitions appear in Figures 17-3, 17-6, and 17-9.

17.4 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment

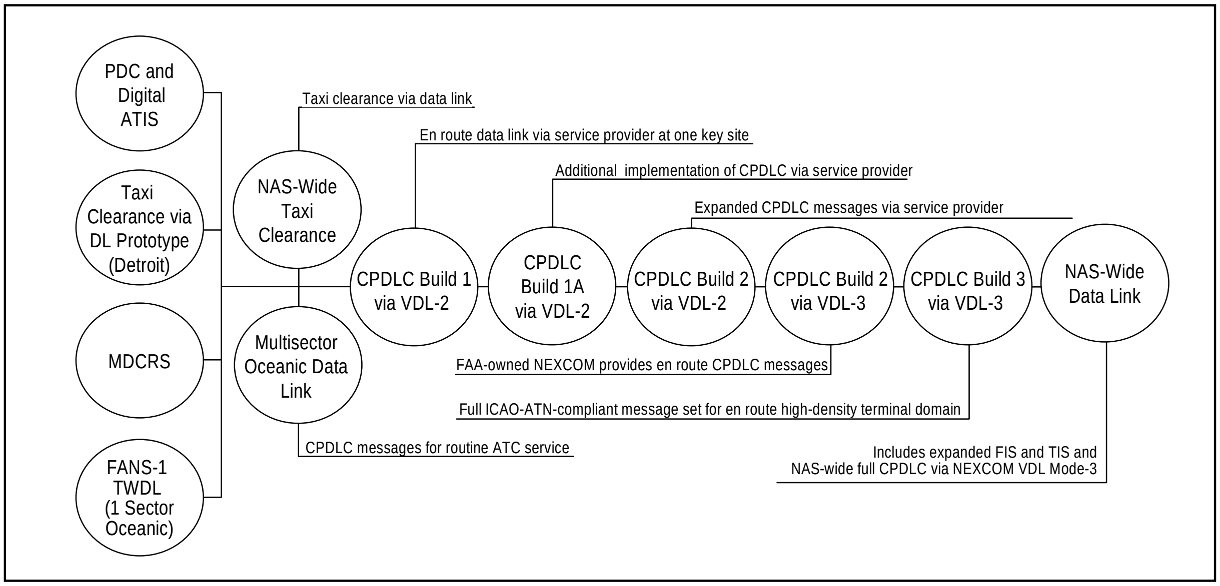

Figure 17-10. Data Link Services Capabilities Summary

(F&E); and operations (OPS) life-cycle costs for the communications and data link architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 17-11.

17.5 Watch Items

The most significant implementation factor in modernizing FAA communications and migrating to Free Flight will be the transition to NEXCOM radios and specification of minimum avionics equipage for all en route and high-density terminal areas. The FAA needs to work through appropriate government and industry forums to develop proposed rulemaking for NEXCOM equipage.

The cost for data link messages needs to be addressed so that the additional cost does not deter users from equipping with the avionics necessary to use the capability.

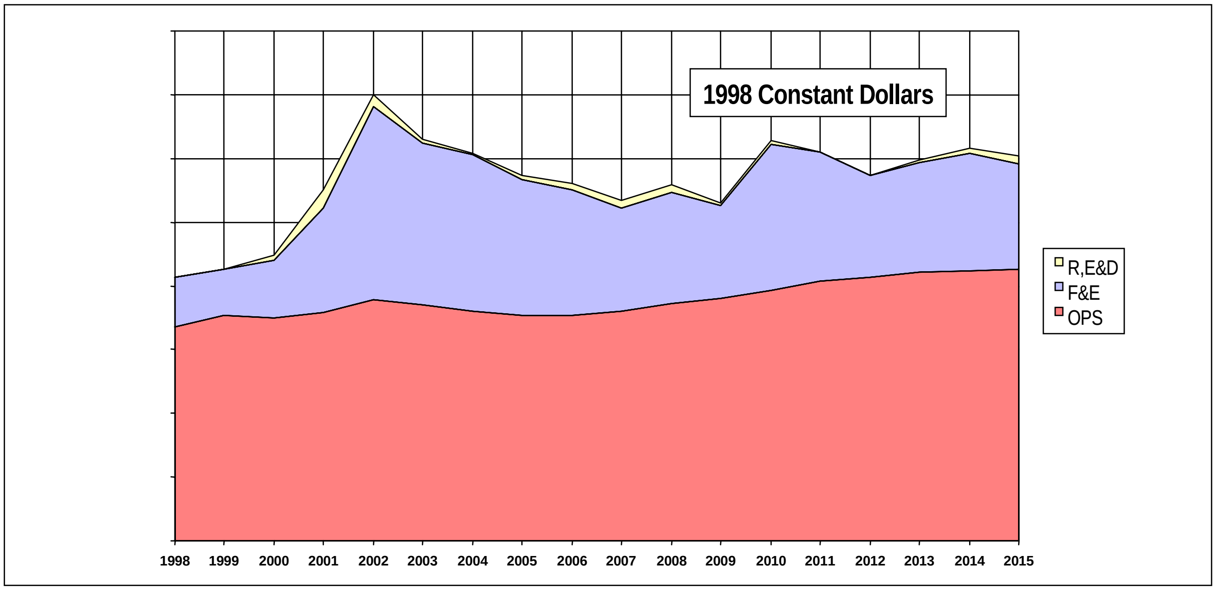

Figure 17-11. Estimated Interfacility Communications and Data Link Costs

18 AVIONICS

The most noticeable and rapid changes in aviation during the past 20 years have been in the avionics equipment available to all user classes, from small general aviation (GA) aircraft to large transport category aircraft. This will continue to be true in the future NAS because new capabilities and air traffic control (ATC) services will depend on avionics equipage. One factor the architecture reflects is the time required for the FAA to certify the new avionics envisioned for the future NAS.

The FAA is responsible for certifying new avionics to ensure the equipment meets acceptable performance and interoperability standards and operates safely. International agreements will be needed to enable worldwide manufacture and interoperability of avionics equipment. Another factor for the architecture is what, if any, changes in minimum avionics equipage requirements will be necessary for operating in the NAS and how to accommodate an aircraft fleet with mixed equipage levels.

Section 4, NAS Operations; Section 15, Navigation, Landing, and Lighting Systems; Section 16, Surveillance; and Section 17, Communications describe a variety of systems (or concepts that will lead to systems) for future NAS capabilities, some of which will require new avionics. New avionics may require new air traffic control procedures and/or aircraft operating procedures (14 CFR Part 91, 135, etc.) before the full benefits of the equipment can be realized.

Equipment (such as avionics) or modification to an aircraft must first be approved through the FAA's certification process. Although there are several ways to receive certification (such as Technical Standard Order Authorization, Supplemental Type Certificate, etc.), in general, each method leads to the same three required approvals: design approval, production approval, and installation approval. This is a very high-level representation of the comprehensive certification mechanism manufacturers must satisfy before installing products on an airplane.

Certification is not a standard process that occurs over a given period of time. Each product to be certified has a unique set of variables that affect the length of the certification process. The following time estimate for avionics certification is used for architecture planning purposes.

Industry collaboration to develop performance standards in a forum such as an RTCA Special Committee can take 2 to 3 years. Once a manufacturer applies for certification, FAA design and production approval can take up to 1 year, and installation approval can take another year. If rulemaking is necessary, it can take 3 to 4 years for a final rule to be issued. However, the rule development process can begin at any time (i.e., rulemaking is not tied to any manufacturer's product design, production, or installation approval). Architecture transition planning estimates account for aircraft equipment certification requirements and possible rulemaking actions (see Section 11, Regulation and Certification Activities Affected by New NAS Architecture Capabilities). RTCA has recently convened Task Force 4, an Industry/Government forum, to review FAA certification processes.

Traditionally, as the NAS evolved, questions about avionics equipage levels were addressed from the viewpoint of allowing user access to airspace while minimizing the equipage cost burdens consistent with safety. The architecture assumes the viewpoint that the benefits from new capabilities and services enabled by future avionics will provide the incentive for operators to equip. However, mixed avionics equipage levels will continue to be a fact of life in the future NAS.

The minimum equipage requirements/mixed equipage issue is complex due to diversity in operations (Part 91, 121, etc.), numerous aircraft types and performance levels, operational conditions (instrument or visual meteorological conditions), and the various airspace classes. Planning remains to be done on the mixed equipage issue to decide what, if any, new avionics minimum equipage requirements or changes in flight procedures will be needed. Therefore, the avionics architecture evolution steps, schedule charts, and cost charts described in this section *do not represent minimum equipage requirements for operating in the future NAS.*[1]

1. Terrain Alert and Warning System (TAWS) is an exception. See Step 1, cockpit displays page 18-4.

PART III

18.1 Avionics Architecture Evolution

The avionics architecture evolution steps estimate the time periods when avionics should be available to support the capabilities described in the communications, navigation, and surveillance sections.

18.1.1 Avionics Architecture Evolution—Step 1 (Current–1998)

Navigation

Aircraft avionics include a variety of navigation signal receivers such as very high frequency omnidirectional range (VOR), distance measuring equipment (DME), nondirectional beacon (NDB), tactical air navigation (TACAN), instrument landing systems (ILS), Long Range Navigation-C System (Loran-C), and the Global Positioning System (GPS) (either visual flight rules (VFR)-only or Technical Standing Order (TSO)-C-129-compliant). These receivers, which are built to international standards, are compatible with the NAS navigational aids infrastructure. Avionics receivers are usually installed in aircraft in various combinations to provide navigation, nonprecision, and precision instrument approach guidance to pilots, using signals from receivers displayed on various flight instruments and displays.

More sophisticated aircraft are equipped with flight management systems that process information from the receivers to provide area navigation capability, although GPS is making area navigation more readily available to low-end users as well.

From an avionics-equipage perspective, there are few problems with the current navigational receivers other than the number that must be installed for navigation. Equipment is affordable, reliable, and internationally interoperable. In some terminal airspace, there is potential interference from frequency modulation (FM) broadcast signals with localizer signals. Additionally, ILS installation costs and problems in obtaining a suitable frequency limit the number of airports that can have precision approaches.

Surveillance

Most aircraft that use NAS and ATC services are equipped with highly reliable and affordable transponders. In general, aircraft are not permitted to fly above 10,000 feet or in certain terminal airspace unless they are transponder-equipped. When interrogated by a secondary surveillance radar (SSR), aircraft transponders reply with the aircraft's altitude and assigned identification code, which is then displayed on controller workstations. Transponders also respond to interrogations from airborne traffic alert and collision avoidance systems (TCAS). TCAS I includes a pilot display that identifies the location and relative altitude of nearby transponder-equipped aircraft. Aircraft equipped with TCAS II also provide pilots with a vertical resolution advisory to prevent mid-air collisions. Most domestic passenger-carrying airplanes with 10 to 30 passenger seats are required to have TCAS I; airplanes with more than 30 passenger seats must have TCAS II.

Communications

In the domestic environment, pilots and air traffic controllers use very high frequency (VHF) amplitude modulation (AM) radios for communicating and receiving air traffic control service information and in-flight weather information. Department of Defense (DOD) aircraft use both VHF and ultra high frequency (UHF) radios for air traffic control services. The FAA also uses the VHF spectrum to broadcast either recorded or automated weather observations of airfield conditions.

All aviation safety communications services for the U.S. oceanic regions use high frequency (HF) voice communications via a commercial service provider. The airlines also use ARINC's HF Data Link services or FANS-1/A-compliant equipment for data link services on transoceanic flights.

Some difficulties and limitations associated with communications in the NAS were identified in Section 17. Due to the growth in aviation activity, voice channel congestion is occurring. In some locations, the VHF spectrum is saturated to the point that no additional channels are available to expand existing ATC services or accommodate new services, such as the Automated Terminal Information Service (ATIS), or automated weather observations. Spectrum availability is one of the critical limiting factors to expanding NAS services and meeting growing demand.

Users, particularly the GA segment, have expressed a desire for a new universal data link communications capability to receive flight information services (FIS), such as updated weather forecasts, hazardous weather advisories, and/or graphical weather depictions in the cockpit. Commercially provided FIS services that include electronic messaging as well as weather information are becoming available for low-end GA users. Traffic Information Service (TIS) via Mode-S using the 1030/1090 MHz spectrum is addressed in Sections 16 and 17.

Cockpit Displays

Aircraft with electronic flight information systems (EFIS) can display a variety of information, such as navigation routes, onboard weather radar data, and TCAS information. EFIS displays are currently used to replace analog gauges with digital multifunction electronic displays; however, their functionality remains similar to that of the analog gauges they replace. Initial displays with limited multifunction capabilities are also available to low-end GA users.

One primary concern for all aircraft is the limited amount of panel space available for avionics and displays. This highlights the need for integrated avionics equipment and displays, which will take up less space than today's piecemeal, stand-alone systems. Integrated avionics suites are more prevalent on air carrier and high-end GA aircraft with EFIS displays and flight management systems. However, even these aircraft have problems resulting from add-on stand-alone equipment, and not all air carrier or corporate aircraft have EFIS displays or flight management systems.

During Step 1, terrain awareness capability is available for air carriers and high-end GA aircraft through ground proximity warning systems (GPWS) that provide aural warnings when an aircraft is close to the ground. An enhanced terrain awareness warning system (i.e., the terrain alert and warning system (TAWS)) that provides more warning time than GPWS is becoming available. TAWS uses position data from a navigation system, such as a flight management system (FMS) or GPS, and input from a digital terrain data base to display surrounding terrain. The computer sends warning alerts to the plane's audio system and displays in the event of a potential collision with terrain. The TAWS computer can input display data to either the weather radar, EFIS, or some other display screen on which the surrounding terrain is shown with the threatening terrain highlighted.

Currently, some air carriers are voluntarily equipping with TAWS, and the FAA has released a notice of proposed rulemaking to mandate TAWS equipage. During Step 2, the FAA will mandate TAWS equipage to replace GPWS as the standard terrain warning system. TAWS will be required on all U.S.-registered turbine-powered airplanes with six or more passenger seats.

18.1.2 Avionics Architecture Evolution—Step 2 (1999–2003)

Safe Flight 21, a limited operational demonstration, will be a key step toward mitigating the scheduling and technological risks associated with NAS modernization. Safe Flight 21 is important to the avionics architecture evolution because the safety and efficiency benefits of modernization outlined in the overall architecture depend largely on avionics. The Safe Flight 21 program will test the avionics and ground infrastructure as a whole. Results from the Safe Flight 21 program will be used to refine the architecture, including avionics evolution. See Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone, for a more complete discussion of the Safe Flight 21 program.

Navigation

In Step 2, GPS avionics capabilities will have at least three distinct levels of sophistication: (1) a GPS receiver for en route navigation and nonprecision approach capability; (2) a GPS Wide Area Augmentation System (WAAS) receiver with precision approach capability (Category (CAT I); and (3) a GPS Local Area Augmentation System (LAAS) receiver with CAT I/II/III precision approach capability. WAAS and LAAS are designed to provide a level of service equivalent to or better than ground-based systems. The architecture supports dual operations, from WAAS initial operating capability (IOC) until the ground-based navigation system phase-down is complete. This provides ample time for users to transition to GPS avionics and for the FAA to ensure that augmented GPS (WAAS/LAAS) operates as designed.

During this time frame, traditional ground-based navigation aids will continue to be available and studies will be completed to determine what, if any, ground-based navigation aids should be retained to supplement augmented GPS. If unforeseen problems arise, the architecture will be adjusted and phase-down of ground-based navigation aids will be appropriately modified. The FAA will not transition entirely away from ground-based navigation aids until it is certain that augmented GPS meets required performance. DOD will conduct an analysis to determine what GPS avionics capability is suited to its worldwide military mission, as well as to the NAS.

When purchasing equipment, all instrument flight rules (IFR) users will have to consider the cost of GPS navigation data base updates. IFR GPS navigation data bases must be updated every 28 days to match the cycle for chart and approach plate updates that reflect navigation/approach changes in the NAS. Currently, the cost to update low-end GA GPS navigation data bases is $500 to $700 per year.

Surveillance

Air-air automatic dependent surveillance broadcast (ADS-B), using GPS as the primary source of navigation data, will be available for pilot situational awareness. ADS reports will include aircraft identity, position, velocity vector, and other essential information. ADS-B-equipped aircraft within the proximity of another ADS-B-equipped aircraft can receive the broadcast, decode the position data, and display the received position on a cockpit display. Air-air ADS-B will require special avionics, GPS or FMS area navigation capability, and a cockpit display, including interfaces for the various components. Broader application for ATC surveillance will depend on creating an ADS ground infrastructure.

In Step 2, TCAS remains as an independent air-air collision avoidance system. ADS-B avionics will operate on a noninterference basis with TCAS-only-equipped aircraft. During this step, the existing equipage requirements for transponders and TCAS will remain in place and no change will be required for TCAS software, due to ADS-B. Also, Mode-3/C transponders will still be in use, operating seamlessly in the same system.

In the oceanic environment, the FAA will begin installing the necessary infrastructure to support automatic dependent surveillance addressable (ADS-A) operations. The main incentive for users to equip with ADS-A avionics will be access to selected oceanic tracks that permit more optimum flight profiles. Additionally, air-air ADS-B avionics will be used to support in-trail climbs/descents in the current oceanic track system.

Communications

In collaboration with industry, the FAA will finalize standards for next-generation communications system (NEXCOM) VHF digital link (VDL-Mode-3) radios that have digital voice and data capability. VDL-Mode-2 digital data services through a commercial service provider will be available to properly equipped users during this time frame. The current VHF (and UHF for DOD) amplitude modulation system will remain in use for voice communications. FIS services will continue to be available through commercial service providers.

During Step 2, HF voice and data link will continue to be the primary communication links in the oceanic area. However, voice and data communications via geostationary (GEO) satellites will become more prevalent because satellite communications will be the primary link for ADS-A capabilities.

Cockpit Displays

New cockpit display avionics will provide information to the pilot in textual and graphical format including ATC clearances and messages, traffic information, moving maps, terrain displays, weather, aircraft and flight monitoring, and other information. These capabilities will offer improved flight safety, efficiency, and flexibility, particularly for GA users. A flight computer is usually required to process the information and drive the displays. Sophisticated transport aircraft and business jets will begin the transition to text and graphic displays using their EFIS systems and initial air-air ADS-B and VDL-2 data link capabilities.

The Safe Flight 21 program will provide the operational testing environment for developing integrated cockpit displays and multifunctional avionics, particularly for low-end GA. The results will be used by the FAA to create appropriate standards for cockpit displays in all user categories consistent with the concepts in the NAS architecture.

18.1.3 Avionics Architecture Evolution—Step 3 (2004–2007)

Navigation

The transition to GPS-based avionics for navigation will continue in Step 3. Traditional ground-based navigation systems will remain in service but will begin phase-down. The FAA projects that by the end of Step 3 or in early Step 4:

- GPS WAAS avionics will be installed in 65 percent of the GA fleet and 100 percent of the GA business and air taxi fleets.
- 100 percent of the air carrier, regional, and commuter fleets will equip with a GPS WAAS/LAAS receiver.

DOD avionics may be based on the precise positioning service (PPS) signal available only to the military and authorized users, rather than on WAAS. During Step 3, DOD will start to equip its fleet (approximately 16,000 aircraft) with GPS avionics suitable for the NAS.

Surveillance

During Step 3, the FAA will begin installing ADS ground stations in nonradar en route areas and at major airports to use ADS-B for air-ground and airport surface surveillance. Aircraft with ADS-B avionics will provide a periodic broadcast of the aircraft's position, velocity, altitude, identification, and other information. Mode-3/C transponders will still be compatible with the NAS radar surveillance infrastructure.

TCAS will be retained as an independent collision avoidance system and the equipage requirements for TCAS and transponders will remain in place. ADS-B will be complementary to TCAS, but will not require software changes or replacement of TCAS equipment. The proliferation of air-air surveillance systems will enable broader application of pilot self-separation procedures and rules.

In the oceanic environment ADS-A and air-air ADS-B avionics will be used, along with navigation, ATC communications, and automation improvements, to reduce aircraft separation.

Communications

The FAA will begin replacing approximately 40,000 VHF radios with new digital NEXCOM radios that have both digital voice and data capabilities. The radios will be able to emulate the existing analog system and can be designed so that selected modulation techniques are software programmable. A phased transition to NEXCOM avionics will begin during Step 3 to provide VDL-Mode-3 service to users in the super high and high en route sectors (above flight level (FL) 240).

The FAA is considering mandating NEXCOM equipage for operators in these en route sectors during Step 3 because the transition depends on all aircraft in the airspace being equipped with a suitable digital radio. DOD will be exempt from any NEXCOM mandates and will continue using UHF for voice communications. Other en route sectors and terminal areas will continue to use VHF analog voice communications or NEXCOM radios in analog emulation mode. Users will be motivated to equip with digital radios mainly because of the reduced operational constraints from frequency congestion.

Cockpit Displays

New multifunctional displays will continue entering service at all levels to integrate data and information from systems such as TIS, FIS, ADS-B, GPS, etc.

18.1.4 Avionics Architecture Evolution—Step 4 (2008–2015)

Navigation

The architecture assumes that IFR users will complete their transition to GPS-based avionics during this time period. This will allow the FAA to complete the phase-down for traditional ground-based navigation systems, but some may remain in service if navigational system redundancy is warranted. GPS equipage will depend on user evaluation of operational need and any minimum equipage requirements the FAA may mandate. Those that fly VFR only will continue to do so and will either not have GPS at all or will equip with a noncertified VFR-only unit. Those that fly IFR down to CAT I precision approaches will equip with WAAS avionics or continue to use current TSO C-129 equipment and accept the non-

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precision approach limitation. Those that currently fly to CAT II/III minimums will equip with LAAS.

Surveillance

Installation of ADS ground systems will be completed in the terminal and en route airspace, thus extending use of ADS-B for air-ground and airport surface surveillance. Aircraft equipped with TCAS and Mode-3/C transponders will still be compatible with the NAS infrastructure. ADS-B will be integrated with the future emergency locator transmitter (ELT) to provide discrete identification codes and GPS-based position information to enhance search and rescue operations.

TCAS will remain as an independent collision avoidance system, but the FAA may accept air-air ADS-B as an alternate means of complying with the collision avoidance mandate. The alternate compliance finding will depend on collecting data that prove air-air ADS-B is no less capable than TCAS. This data collection may be done during the Safe Flight 21 program. Additionally, implementing a TSO and changing existing regulations will have to be accomplished before air-air ADS-B can be substituted for TCAS.

Communications

As the transition to NEXCOM progresses, more ATC sectors will convert to digital communications, commensurate with user equipage. Flight information services such as weather information and notices to airmen (NOTAMs) will be available via the NEXCOM data link. During this step, the FAA is considering mandating NEXCOM radios at FL 240 and above as well as in selected high-density terminal airspace and some associated low-altitude en route sectors. Low-density terminal areas and en route sectors below FL 240 will continue using NEXCOM radios operated in analog emulation mode. DOD will be exempt from any mandated requirements and continue using UHF for air traffic services to allow more time to equip its significantly larger fleet.

Low and medium earth-orbiting (LEO/MEO) satellite systems will become available as an alternate means of ADS-A-compliant voice and data link communications for oceanic areas. Users will have a wider selection of avionics options because GEO and HF voice and data link systems will remain in use as well. Cost versus flexibility to fly optimum tracks and profiles will be a determining factor in how users choose to equip.

18.2 Human Factors

NAS modernization will invoke or accommodate significant changes on flight decks, such as using multifunction displays that present information on the location of proximate aircraft, weather, terrain, and other flight information. Human factors activities will be required in the development of avionics standards and installation, training, and maintenance guidelines. These include:

- Developing human factors requirements and standards for avionics certification
- Establishing human factors installation guidelines for retrofitting advanced avionics into older aircraft
- Developing, implementing, and assessing human factors training requirements for pilots, controllers, and maintenance technicians
- Standardizing avionics displays among different manufacturers.

18.3 Transition

Figure 18-1 shows the ground infrastructure transition to support avionics equipage and the anticipated transition for cockpit displays.

18.4 Costs

Table 18-1 shows estimated avionics equipment costs separated into four user-categories. The air carrier category represents major, national, and regional airlines flying all-jet fleets in Part 121 passenger or cargo revenue service. The mid-range category represents commuter, air taxi, and corporate GA flying turboprop, jet, or large multi-engine piston aircraft under Part 91, 121, or 135 regulations. The low-range category represents small single- or twin-engine piston aircraft operated under Part 91 regulations. The military category represents the full range of DOD aircraft from helicopters to cargo transports.

However, the lines between categories are often blurred because of aircraft type, performance, or operational use, and some aircraft or operations do not fit neatly into the defined categories. For instance, the New Piper Malibu, which is a single-engine piston aircraft, has the performance to be used in a Part 135 air taxi or small corporate aircraft operation. Similarly, one model of the Boeing 737, which normally fits the air carrier category, is being marketed as a corporate aircraft to compete against other high-end business jets with similar performance.

Table 18-1 provides a range estimate of nonrecurring costs for avionics equipment only. The table does not include items such as installation, or recurring costs for training or data base updates. The figures in the table are an average compiled from representatives of the avionics manufacturing industry and the military. For equipment, such as GPS/LAAS or ADS-B, the price range is an educated guess or cost goal because there are still too many unknowns relative to performance and certification requirements. For avionics such as EFIS displays or GPS-receiver autonomous integrity monitoring (RAIM), the costs are well known and the price range is based on the wide variety of choices and feature/capability options available.

Another factor that can affect the nonrecurring unit cost is the trend toward integrating avionics equipment rather than building individual, standalone boxes. The trend is particularly prevalent in the air carrier and mid-range categories but is also starting to affect the low-range category as well. One reason for the higher cost of air carrier and mid-range avionics is the higher reliability and performance standards the equipment must meet. For example, avionics on air carrier and high-end GA aircraft are typically built with more redundancy than equipment for low-end GA. The military has additional specifications that increase cost, such as resistance to electromagnetic pulse, ruggedizing equipment for high G loads, secure anti-jam system requirements, etc. Future architecture efforts must focus on what, if any, mandatory equipage requirements will be needed and by when.

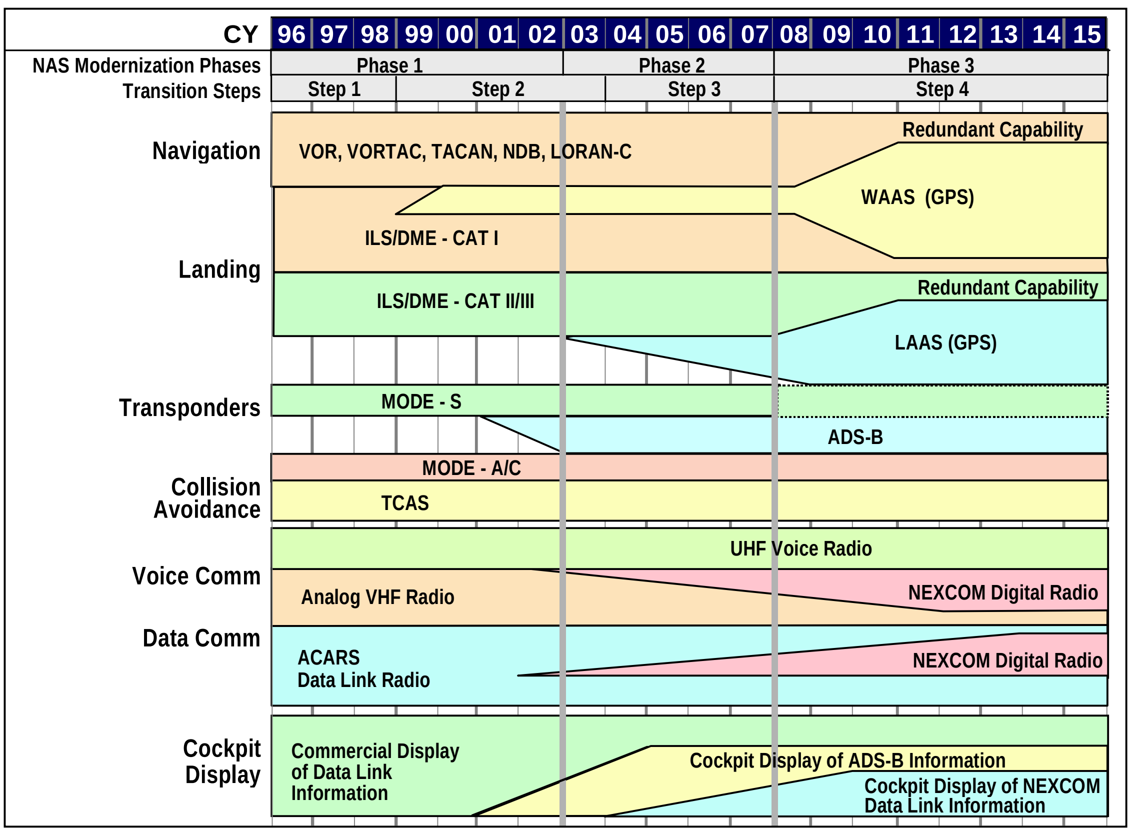

Figure 18-1. Ground Infrastructure Transition Supporting Avionics Equipage

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Table 18-1. Estimated Avionics Costs (1998 Dollars)

Avionics	Air Carrier	Mid Range	Low Range	Military
Communication:				
Digital Radio (voice)	$10-20K	$10-20K	$4-5K	$60-80K[8]
CMU (data)	$25-45K[10]	$15-30K	$7-9K	$15-30K[12]
Cockpit Displays:				
TAWS	$47-50K[2]	$47-50K[1]	N/A[9]	$47-50K
EFIS	$200-229K	$40-229K[7]	N/A	$40-80K[13]
MFD	N/A	N/A	$10-12K[5]	N/A
FIS (Weather)			$6-8K[4]	N/A
Navigation:				
GPS-RAIM	N/A	$8-10K	$3.5-9K	$13-14K
GPS-WAAS	integ. with LAAS	$12-15K	$5-10K[3]	TBD
GPS-LAAS	$15-30K[11]	$15-30K[16]	N/A	TBD
Surveillance:				
ADS-A (Oceanic)	$700-775K[14]	$560-620K[15]	N/A	$800-1,000K[17]
ADS-B (Data Link)	$25-35K[20]	$25-35K	$5-7K[6]	$55-65K[18]
Mode-S	$20-30K[19]	$20-30K	$4.5-5.5K	$20-30K

1. Non-EFIS-equipped aircraft may have less capable system with regionalized data base and no reactive windshear costing between $15 and 20K.
2. For digital or analog data bus, includes reactive windshear. Requires EFIS display.
3. Additional costs may be incurred for annunciator lights or new course deviation indicator.
4. Includes dedicated display. Service available on laptop computer provided by operator for 1.5 to 2.0K.
5. Excluding equipment that provides information to display.
6. Includes basic Mode-S with ADS- B card and receiving/processing TIS information (no display). Predicts transponder cost decrease due to integrated functions and increased user equipage.
7. Price depends on how sophisticated/how many display tubes the EFIS has, i.e., a one-tube basic system versus a five- or six-tube high-end system.
8. Includes military-unique requirements such as secure communications capability.
9 Certified TAWS probably will not be available for small aircraft. However, noncertified TAWS-like capability will be available as part of MFD software packages.
10. Cost is dependent on several factors, such as range of features selected.
11. Cost presented here is an estimate for an integrated WAAS/LAAS receiver.
12. FAA will continue to support the UHF infrastructure for DOD use.
13. Costs vary depending on aircraft type and features selected.
14. Data from Industry Customization Working Group using B767 example. ADS-A is not sold as stand-alone equipment; it is part of FANS package, including display, FMC, CMU, etc., and hardware/software upgrades. Low figure is for FANS-1/A package without CPDLC capabilitiy and excluding GPS. High figure includes CPDLC capability. Add $260K for CNS/ATM-1-compliant package.
15. Industry Customization Working Group estimates that mid-range costs are approximately 15 to 20 percent less than air carrier costs. Add $220K for CNS/ATM-1-compliant package.
16. Cost for integrated WAAS/LAAS system similar to air carrier.
17. Complete FANS-1/A, CNS/ATM-1-compliant package, including displays, hardware, software, and military-unique requirements.
18. Includes TCAS II equipment with provisions for ADS-B add-on and military-unique requirements.
19. Airlines are required to have two transponders.
20. Mode-S with ADS-B card. Non-EFIS-equipped aircraft will also require a dedicated display costing approcimately $20K.

18.5 Watch Items

- Establish minimum equipage requirements with appropriate user input
- Review and implement RTCA Task Force 4 recommendations on certification.

19 NAS INFORMATION ARCHITECTURE AND SERVICES FOR COLLABORATION AND INFORMATION SHARING

The NAS information services offer a new collaborative capability for information sharing between FAA and NAS users and througout the FAA. Information sharing will be improved across all domains and with other organizations that need this information. Generating, processing, and distributing information is an integral part of the NAS. As emphasized in the Air Traffic Services (ATS) concept of operations (CONOPS), information exchange is essential to safe and efficient NAS operations.

The collaboration envisioned for the future is a complex process that is being jointly explored by the FAA and the user community. Collaboration and information-sharing services will evolve as experience is gained. Information exchange begins with data exchange as it now exists and then evolves to the collaborative process, as illustrated in Figure 19-1. The goal of an evolutionary approach is to begin collaboration as early as possible.

In the collaborative decisionmaking process, *users* make decisions associated with their operations (e.g., the priority of a particular flight leaving a location). *Service providers* make decisions associated with NAS resources (e.g., airspace and airport capacity during adverse weather conditions).

The NAS information services are based on consistent information exchange among NAS systems. These services, for the most part, are a result of system interoperability that is transparent to collaboration users and is provided through consistent interfaces developed for each system. To achieve interoperability, coordinated interfaces for data exchange among FAA and NAS user systems must be established during systems development.

Currently, NAS information is managed primarily within individual systems. Overall, this creates many inconsistent and inefficient local information management operations that are based on widely varying standards, definitions, and data structures. The future NAS information systems will make interoperability easier to achieve and more cost-effective. As the NAS grows more complex, system interoperability will become a necessity. Data standardization will support implementation of a common, flexible system with consistent interfaces between systems and which offers more options for the aviation community to share data with and retrieve data from the NAS.

19.1 Information Services Evolution

The NAS information services will be allocated, tailored, and integrated at three levels:

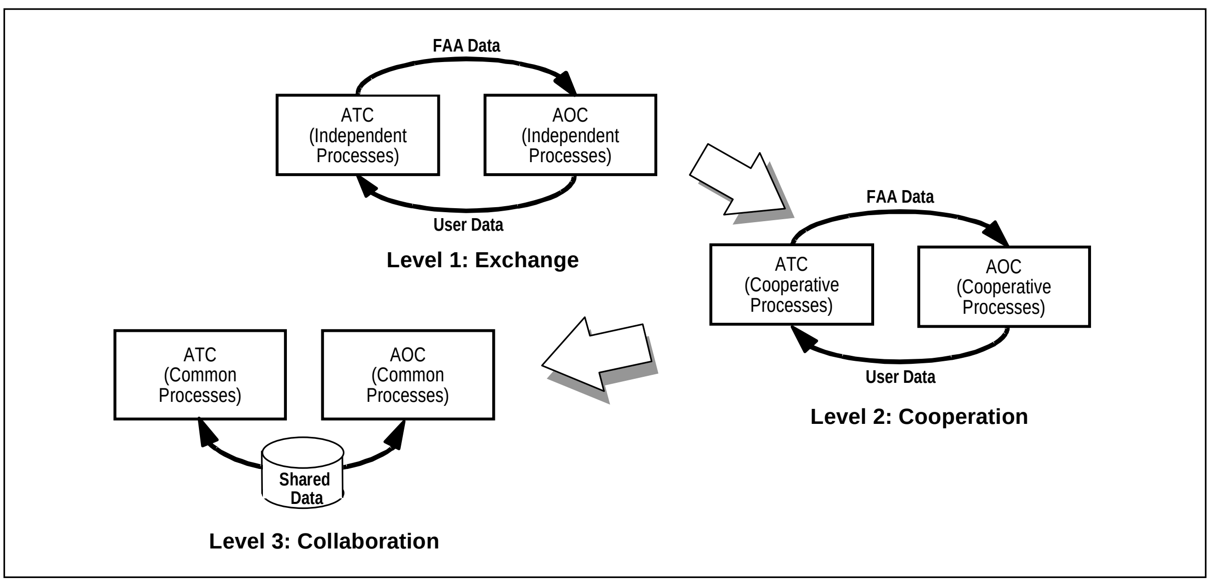

Figure 19-1. Evolution of Collaboration and Information Exchange

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- Data standardization and interoperability across applications
- The local or facility levels
- The NAS-wide level.

Each of these will manage and maintain appropriate information for internal use and exchange with other users. Figure 19-2 shows the four major information end-user groups:

- FAA service providers
- Flight planners
- Aircrews
- Aviation auxiliary or indirect users.

A goal of NAS information services (in support of the CONOPS) is to share information seamlessly across these organizational boundaries; this requires data standardization.

Data Standardization and Interoperability

Data standardization will address how data are exchanged between multiple applications. For example, it will ensure compatibility between Center TRACON Automation System/Traffic Management Advisor (CTAS/TMA) applications and conflict probe (CP) applications within an en route center.

Data standards in existing systems are frequently inconsistent—sources for the same data may vary and formats may be incompatible. Interoperability requires translating data whenever information is transferred from one system to another.

Local- or Facility-Level Information Exchange

Local information systems will interoperate through consistently defined information exchange. As local legacy systems are replaced or new systems developed and deployed, commercial data base management systems will be used where applicable, and information models for all systems will be based on managed data standards.

Information exchange at the local or facility level will be the backbone of information exchange at the national level and with NAS users. Specific data categories—such as local weather data, adaptation data, dynamic and static resource data, flight and demand data, performance data and traffic management demand/capacity data—will be stored within the local information systems as required. The data will be updated and made

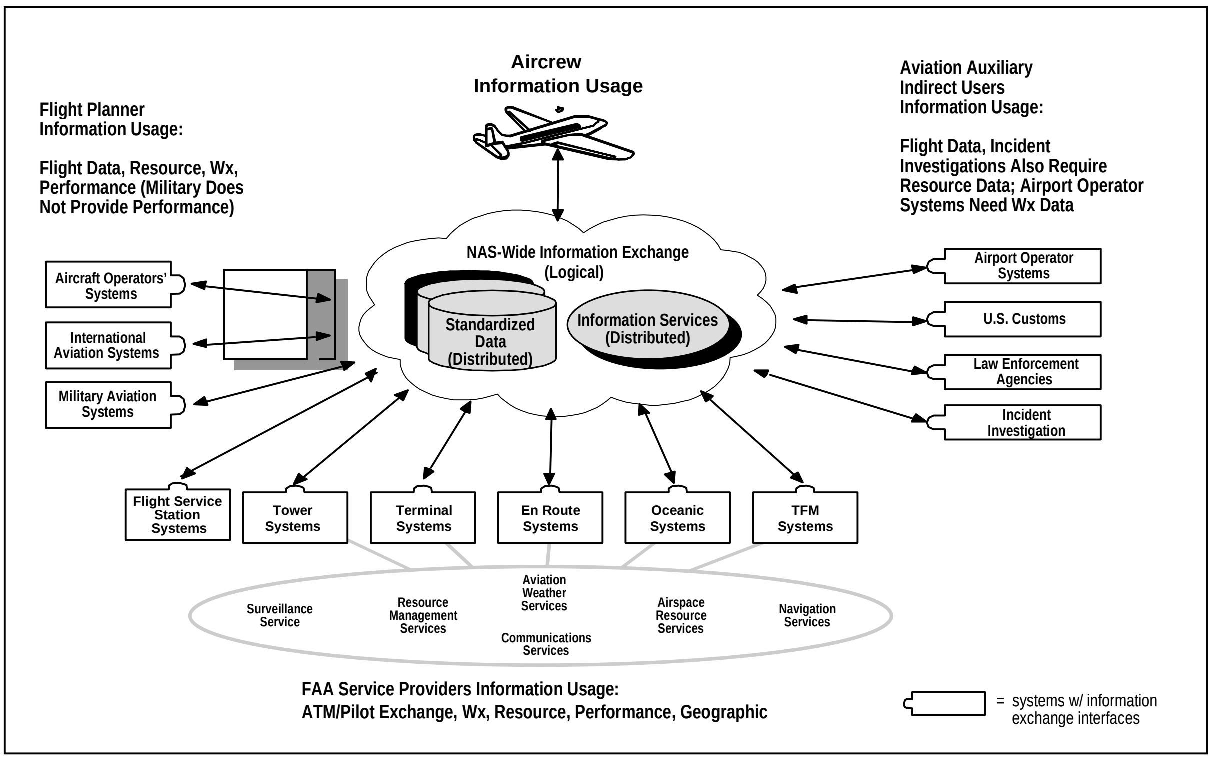

Figure 19-2. Seamless Information Flow in the NAS

available to NAS service providers and users as required.

NAS-Level Common Information Exchange

NAS-level common information systems exchange information across NAS facilities and among NAS service providers and NAS users. These interoperating systems require consistently defined information exchange. As these systems are replaced or new systems are developed, commercial data base management systems will be used where applicable, and information models for all systems will be based on managed data standards.

The standards will involve determining where data come from, who uses the data, how the data are defined, how the data are transformed, and who owns the data. The answers to these questions will help determine the data standards for specific items, such as the flight object (defined as flight plan information and other information, such as preferred runway and taxiway). It will include International Civil Aviation Organization (ICAO) flight-plan-compatible data and will be available to all authorized users, as defined during development of each system.

In some cases, such as for the aggregation and integration of airspace and airway adaptation data, no single authoritative NAS-level information system exists. Systems for such information services will be developed as NAS-wide resources.

The local and NAS-level common information exchange will evolve as depicted in Figure 19-3. These increments comprise a four-step evolution. The first step describes current information services. The second step establishes data standards (including definitions, sources, and formats) for achieving efficient interoperability among legacy systems (near-term view). The structured data can then be stored in external storage media, where the data will be directly accessible by external applications (mid-term view—Step 3). The target view (Step 4) represents the best in system interoperability in which information is easily and unambiguously exchanged as required. As it evolves, it will provide information to both users and service providers, taking into account necessary security precautions.

NAS Information Architecture

The exchange of information across the NAS envisioned by the CONOPS will be based on accepted industrywide information architecture principles.

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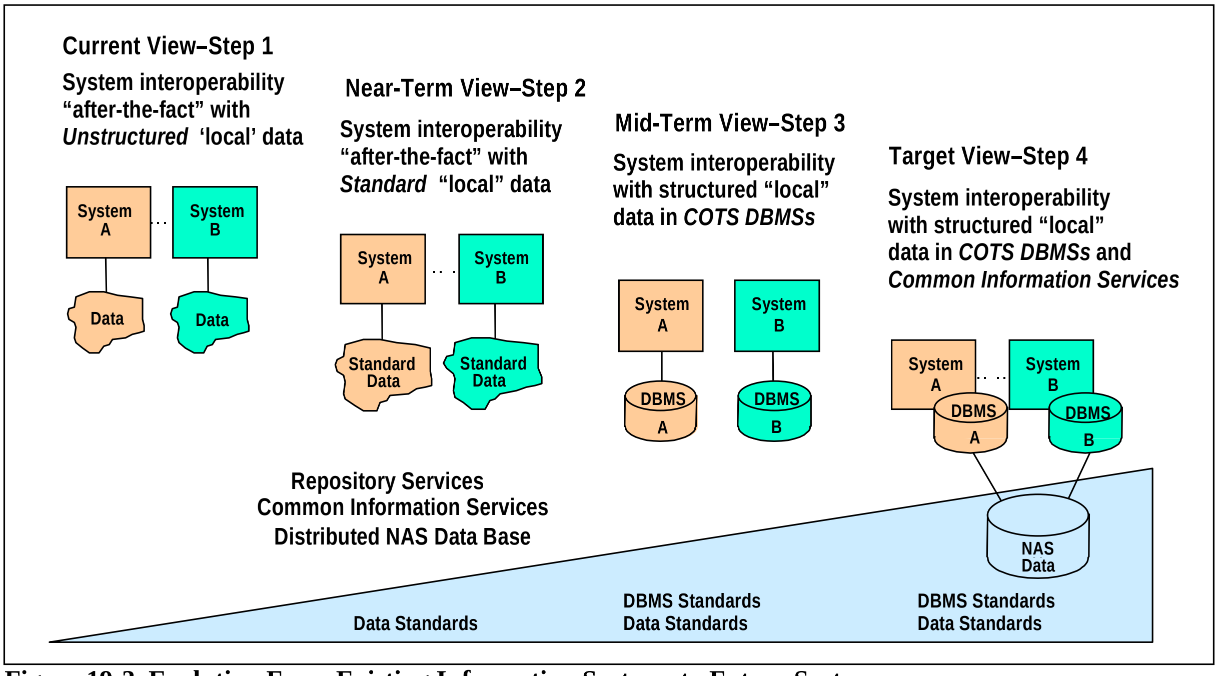

Figure 19-3. Evolution From Existing Information Systems to Future Systems

NAS Information Architecture Goals

The development of the information exchange in the NAS is based on meeting the following four goals:

- *Data Quality and Access:* Supporting the information needs of the many NAS users and service providers with timely, accurate, and complete information via system-to-system, human-to-system, and human-to-human information access
- *Interoperability:* Providing for data exchange, cooperation, and collaboration using data commonly defined by numerous NAS organizations, systems, and users
- *Cost-Effectiveness:* Delivering information in a cost-effective manner and emphasizing information reuse
- *Responsiveness, Flexibility, and Scaleability:* Responding to new functional needs quickly and efficiently.

Local- and NAS-level common information exchange systems will provide information services to foster convenient, widespread, standards-based information exchange supporting both collaborative and better-informed decisionmaking by NAS users and service providers. These systems will manage all types of NAS data, with emphasis on the core types of operational data (i.e., flight, surveillance (positions), NAS resources, and weather data). Both static (i.e., descriptive) and dynamic (i.e., NAS status) data will be managed, and operational data will be used for real-time safety and traffic flow decisionmaking, as well as for pre- and post-event analysis to improve operational performance.

To support data exchange as envisioned, local- and NAS-level information systems will be implemented using a variety of information technologies and tools, including information standards, services, and processes. More importantly, new information management processes will be put in place to achieve coordination across organizations, domains, and systems.

The information exchange will be service-oriented. To be successful, it requires systems that cannot be specified and acquired as a traditional application system. It is a *set of information services* distributed across the NAS and coordinated through a hierarchy of responsibility. This hierarchy of data ownership will enhance operational decisionmaking by providing access to consistent, timely, high-quality NAS information.

How NAS Information Services Are Used

NAS information services will be managed and distributed across the NAS at three levels: NAS-wide, locally, and at the system level. Figure 19-4 distinguishes the basic set of information services by each of the three levels. The issue of data "ownership" is really one of distributed responsibility. The FAA will need to assign new roles (e.g., data administration and data base administration) at the three levels, and NAS users will be responsible for the aspects of information management that naturally fall within their area. For instance, air carriers initiate flight schedules and flight changes; the military manages special use airspace (SUA); and international aviation is active in oceanic airspace.

All three NAS user constituencies will structure their information services consistent with FAA information structures and services and vice versa. They will also have information management responsibilities due to their collaboration on numerous airspace situations, from severe weather (in real time) to ground delays (in near real time) to airspace design (archival/analytic) issues.

For domain-specific implementation information, refer to the domain sections (Section 21, En Route, and Section 23, Terminal). Details of information architecture not described in the domain sections will be developed as part of the information architecture process.

Information services will evolve as software and interfaces for new systems are developed or existing systems are upgraded or replaced. This will require a consistent set of standards and requirements that will apply to new software and operating systems, networks, and interfaces. The evolution is described generically in the following steps.

19.1.1 Information Services Architecture Evolution—Step 1 (Current–2000)

During Step 1, the NAS-level common information exchange implementation is primarily constrained within existing data management ser-

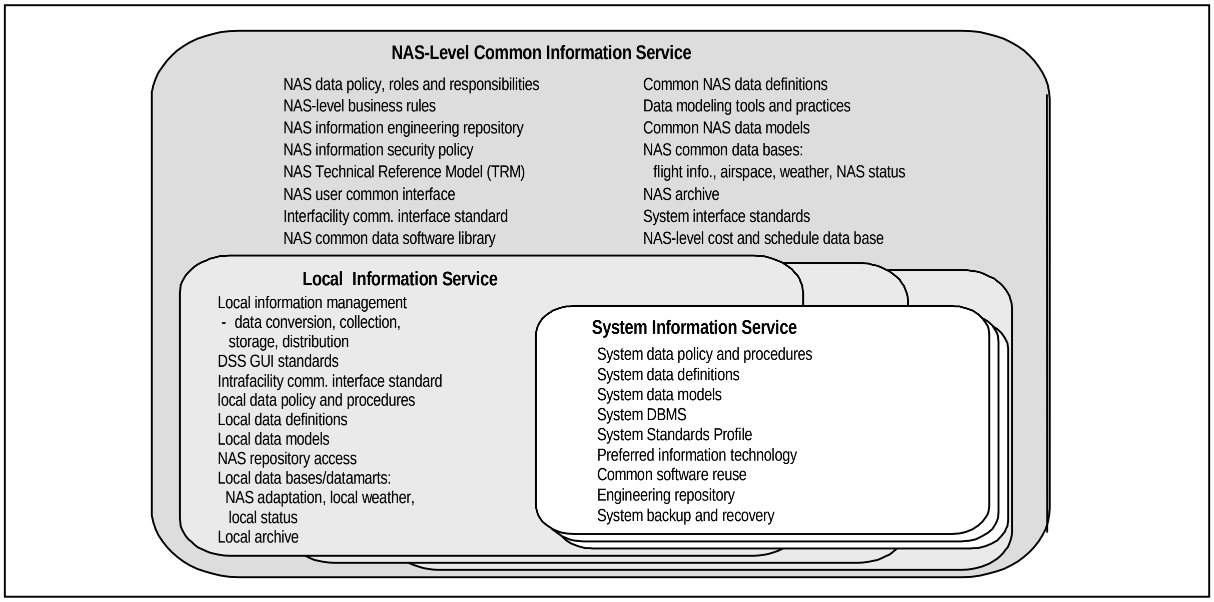

Figure 19-4. Three Levels of NAS Information Services

vices and legacy automation systems. Organizational and technical research groundwork will determine how to move from the way data are currently defined and managed within systems to a way that is compatible with coordinated systems, facilities, and NAS perspective. The initial tasks include:

- Maintaining and augmenting NAS user-to-system and system-to-system exchange of existing data
- Establishing new NAS-wide data management roles and responsibilities
- Baselining existing information definitions and requirements
- Developing data models to help guide the evolution of the information systems.

In transitioning from current information and transmission methods, data will continue to be available in its current form. Some data will remain in its current form in the future (e.g., data available over the Internet). Other data will be added to the current transmission media, particularly the Internet and data link.

19.1.2 Information Services Architecture Evolution—Step 2 (2001–2004)

A set of common, standardized information services supported by the local and NAS-level common information systems will begin to evolve during this step. Determining common data standards and structures will enable establishment of a central data repository for NAS-user access to some local data. Since security systems and procedures will not be fully implemented, external NAS users will access data from data bases established for that purpose, not directly from the applications that generate the data.

The flight object, as described in the CONOPS, significantly changes how flight data will be managed and shared in the future NAS (see Figure 19-5). First, as a replacement for today's flight plan, the flight object is much more comprehensive in scope and encompasses new data such as flight preferences. Second, the responsibility for processing flight object data will be distributed to different systems as a flight moves from preflight planning to in-flight operations to postflight analysis. Third, all data in the flight object associated with a flight will be made available NAS-wide and shared with NAS users as appropriate.

Key activities in the information services evolution during this time frame include:

- Developing requirements and standards for flight object data
- Developing standards for internal interfaces to the local information systems
- Developing standards for interfaces to external NAS users

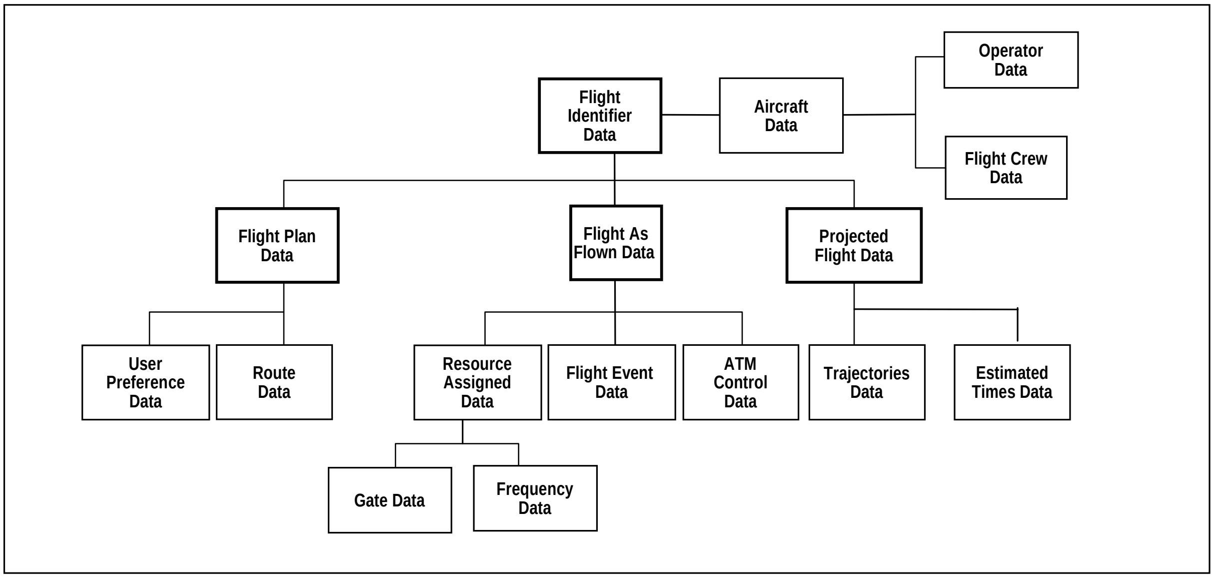

Figure 19-5. High-Level View of the Flight Object

- Implementing data security policies for local and NAS-level common information exchange
- Incorporating local information exchange capabilities into air route traffic control centers (ARTCCs)
- Providing NAS user data, including real-time SUA status and facility status
- Providing security for data access and exchange, as appropriate and available.

19.1.3 Information Services Architecture Evolution—Step 3 (2005–2008)

The set of common, standardized information services supported by the local and NAS-level common information exchange will continue to evolve during Step 3.

Key activities in the information services evolution during this time frame include:

- Developing requirements and standards for NAS resource (facility and airspace) status data
- Beginning deployment of local information system capabilities, tailored to support other facilities
- Providing security for data access and exchange, as appropriate and available.

19.1.4 Information Services Architecture Evolution—Step 4 (2009–2015)

A set of common, standardized information services supported by the local- and national-level information services will continue to evolve. All features—which are currently envisioned for NAS-level common information exchange that supports seamless data exchange within the NAS and with external users—will emerge in this time frame. Additional features will be developed as experience with the evolving NAS-level information services accumulates and as technology and user requirements evolve.

Key activities in the information services evolution during this time frame include:

- Completing and maintaining requirements and standards for all shared NAS data
- Beginning distribution of flight data to NAS users via the NAS-wide information network
- Making flight object data available NAS-wide
- Providing standardized, common data services support for NAS applications
- Providing NAS users access to all authorized NAS data
- Providing security for data access and exchange, as appropriate and available.

19.2 Summary of Capabilities

The modernized information systems will distribute timely, accurate, and consistent information in electronic format across the NAS, resulting in improved services to users, more efficient use of NAS resources, better flight planning, and more cost-effective systems development and acquisition. The information systems will provide users and service providers with a common view of the NAS for collaborative decisionmaking. Common, standards-based data services will provide data collection, validation, processing, storage, and distribution of data to and from data sources that are both internal (e.g., traffic flow management) and external (e.g., the National Weather Service (NWS), airlines, DOD, and international traffic flow managers) to the FAA. Figure 19-6, illustrates collaboration based on the Free Flight concept.

Data will be dynamically updated as situations change. Data types will include:

- *Flight Data:* Such as the filed flight profile and all amendments, first movement of the aircraft, wheels-off time, in-flight position data, touchdown time, gate or parking assignment, and engine shutdown. The current flight plan will be expanded to become the flight object and will include the added information about the flight. The information will be standardized to be consistent with ICAO standards. The user is one of the main sources of this type of data.
- *Resource Data:* Include static resource data, such as NAS boundaries, configurations, runways, and SUAs; and dynamic resource data, such as airport and airspace capacity constraints, current configuration of runways, system infrastructure status, schedule of SUA activity, and schedule of maintenance activity. The FAA is one of the main sources of this type of data.
- *Enhanced Weather Data:* Include current and forecast weather, hazardous weather alerts for windshear events (microbursts and gust fronts) and other hazards such as icing, turbulence, etc.
- *Traffic Management Data:* Include current and anticipated demand/capacity imbalances and planned strategies for managing them.
- *NAS Performance Measurement Data:* Provide information on NAS performance in a meaningful and readily accessible format for better planning.
- *Geographic Data:* Include terrain maps, obstruction locations, airspace boundaries, etc.

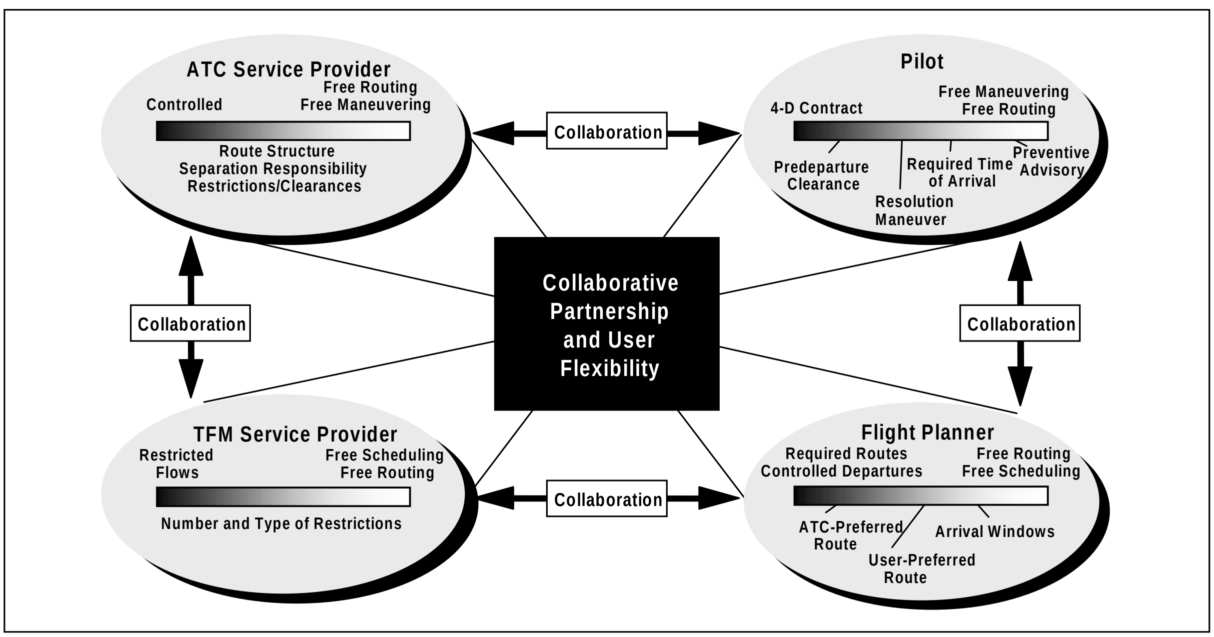

Figure 19-6. Collaborative Decisionmaking in the Future NAS and Electronic Data Exchange for Collaboration

- *Surveillance Data:* Include aircraft-position time and coordinates reports, velocity, and intent information.

The NAS is increasingly dependent on greater information exchange for better and shared planning and decisionmaking. The NAS-wide information network will provide NAS users and service providers with consistent, accurate, timely data to allow for future collaboration.

19.3 Human Factors

The new automation architecture and information-sharing processes will reduce human errors and improve throughput, workload, system confidence, and situational awareness. Human factors goals for this architecture are to:

- Reduce the potential for a human error (e.g., input error, or anomaly in one part of the system to adversely affect the performance of another part or person)
- Base the conceptualization, design, and development of the information interface with the user on the functions people perform and how and when they will be performed
- Define the information architecture in terms that include the user's task-related information requirements and the human component of relevant organizational modeling
- Determine the acceptance criteria for the data structure and standardization using factors that include human performance measures (e.g., for the end-product's utility and usability)
- Devise information architecture suitability and effectiveness measures that relate to operators' and maintainers' time- and event-derived tasks
- Optimize information architecture and implementation to clarify boundaries and procedures for controller and flight crew roles and responsibilities in collaborative operations and interactions
- Develop information architectures that promote the capability for air and ground displays to enhance common situational awareness among various users.

19.4 Information Security

All information service providers are responsible for information exchange security. This includes access privileges, data integrity and availability, and data sensitivity. Security will become a more complicated issue as the local and NAS-level common information systems evolve and as more information is shared among the FAA and NAS users. Protecting the integrity and privacy of FAA and NAS-user provided information will be critical to information exchange effectiveness. For example, users must have confidence in the data they access and confidence that sensitive or proprietary data they provide will be protected. New security systems and procedures will be implemented. See Section 9, Information Security, for a more detailed discussion.

19.5 Transition

The transition timeline for implementation of NAS information services is discussed next. The collaboration and information-sharing transition timeline is shown in Figure 19-7.

Information-sharing capabilities will be implemented during the following time frames:

- Near term: Local information services will include information directory/repository, decision support/data alerts, data management, security, system interface/information sharing, and data archive. Evolutionary steps will be:
  - Provide internal FAA facility information
  - Provide flight data to NAS users (including DOD) external to the FAA facility
  - Provide data access (search and query and publish and subscribe) capability to NAS users (including DOD) external to the FAA facility
  - Develop coordinated interfaces among legacy systems and for new and reengineered systems
  - Develop NAS information services, including data administration, data models, standards, protocols, and common data definitions
- Mid term: Expand information-sharing capability to address other specific information-sharing requirements

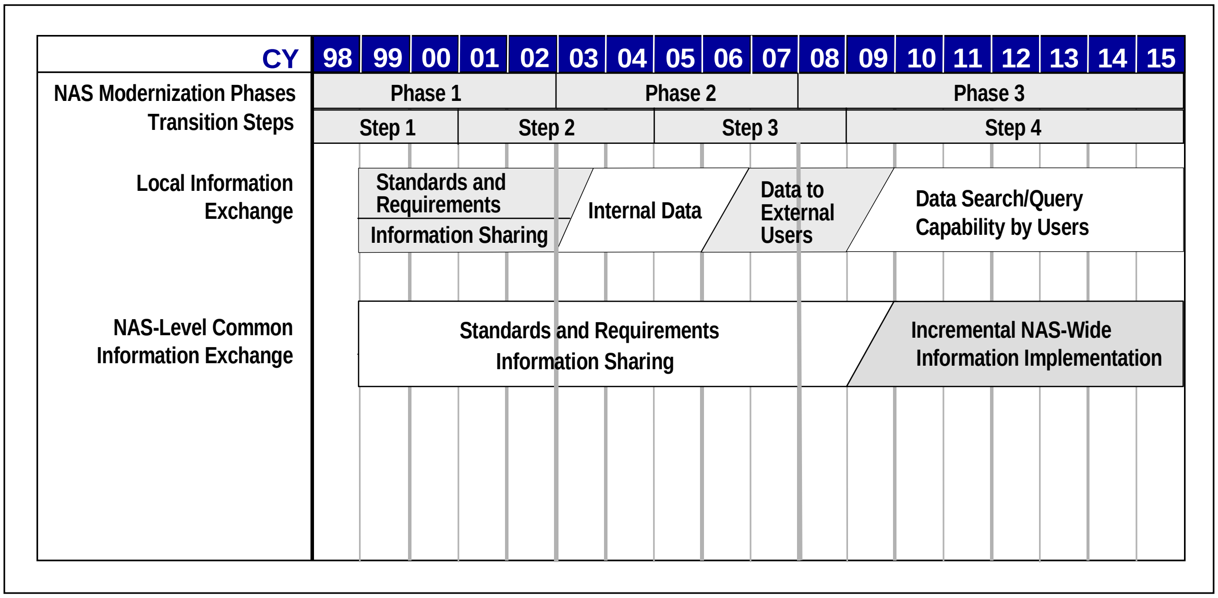

Figure 19-7. Collaboration and Information-Sharing Transition

- Provide demand data, such as flight information (flight object) and flight schedule information
- Provide capacity data, such as radar summaries, airport status, and airspace capacity/status
- Provide notices to airmen (NOTAMs) and weather data, such as hazardous weather warnings
- Implement NAS information services, which includes standards, protocols, and common data definitions

• Far term: Provide information sharing for the NAS operational concept

- Manage overall NAS information
- Plan and coordinate local and NAS-level common system infrastructure, which includes:
  - —NAS data administration services
  - —NAS information technology services
  - —NAS data modeling services
- Maintain NAS information services, which includes responding to changes in standards, protocols, and common data definitions as requirements evolve.

19.6 Costs

Most of the FAA costs for NAS collaboration and information sharing are covered in the interoperablity costs for each NAS system. Other costs are shown in Figure 19-8. They include:

- Information modeling and standards development
- Standards management, validation, and conformance testing
- NAS-wide engineering knowledge repository development, implementation, and operations and maintenance
- Specific NAS-wide data bases such as a central adaptation data system.

19.7 Watch Items

- Identify priorities for delivery of collaboration information with users
- Establish policies for collaboration and information sharing. These policies are for:
  - Authorizing access to specific classes and types of data for FAA and NAS users
  - Allocating integration and interoperability responsibility among system developers, including clear guidance for commercially available versus developmental tradeoffs
  - Accommodating ad hoc legacy systems for system interoperability and information

PART III

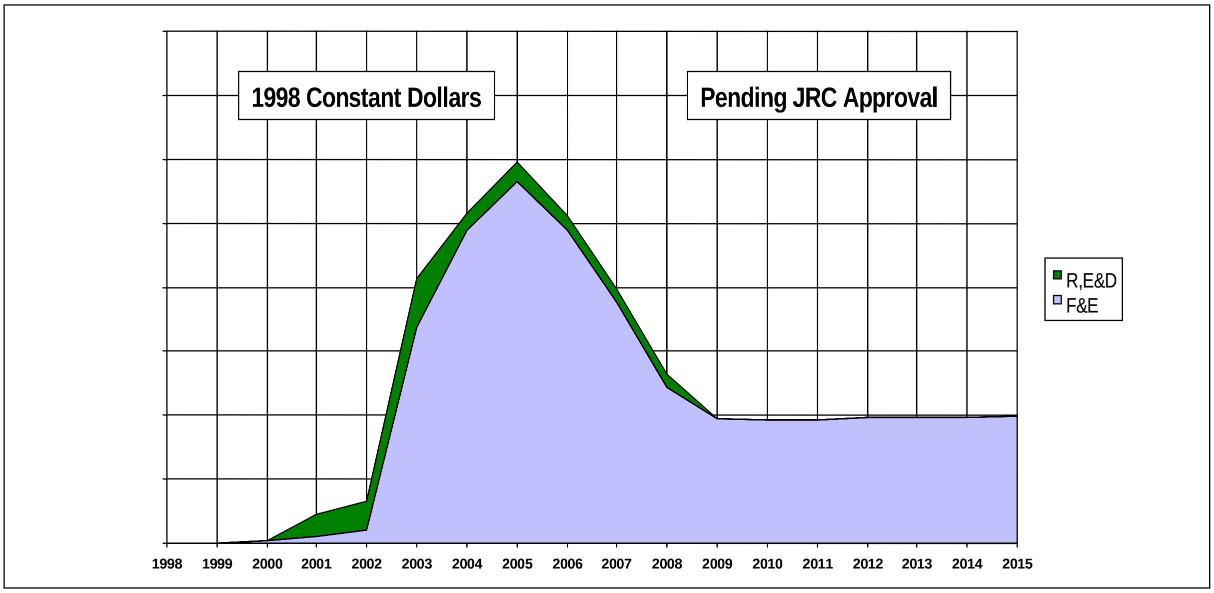

Figure 19-8. Estimated Collaboration and Information-Sharing Costs

exchange (e.g., operational data management system (ODMS), Systems Atlanta Information Display System (SAIDS), special use airspace management system (SAMS), etc.). These systems are currently used within the NAS to meet operational needs, but no requirements exist to access the data, or transition these needed capabilities into developmental systems.

20 TRAFFIC FLOW MANAGEMENT

Air traffic management (ATM) encompasses traffic flow management (TFM) and air traffic control (ATC) capabilities and is designed to minimize air traffic delays and congestion while maximizing overall NAS throughput, flexibility, and predictability.

This section addresses the functionality and evolution of the national and local TFM components of the ATM architecture. The description of TFM functionality includes capabilities at the Air Traffic Control System Command Center (ATCSCC) with some functionality distributed to traffic management units (TMUs) at air route traffic control centers (ARTCCs), at high-activity terminal radar approach control (TRACON) facilities, and at the highest-activity airport traffic control towers (ATCTs). To avoid duplication, only TFM functionality is described in this section. For descriptions of ATC functionality, see Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface.

TFM is the strategic planning and management of air traffic demand to ensure smooth and efficient traffic flow through FAA-controlled airspace. To support this mission, traffic management specialists (TMSs) at the ATCSCC and traffic management coordinators (TMCs) at local facilities (ARTCCs, TRACONs, and towers) use a combination of automation systems and procedures known collectively as the TFM decision support systems (DSSs). Modernizing the TFM DSSs includes new capabilities that will provide:

- More timely and precise data exchange between traffic managers and airline operations centers (AOCs)
- Enhanced analytical and display capabilities to facilitate FAA and industry collaboration in response to temporarily reduced NAS capacity
- More precise tools to analyze flow control data, performance, and decisionmaking.

These TFM DSS enhancements are expected to reduce industry operating costs by reducing flight delays, providing more predictability, and giving users operational control over their resources. Presently, sites with operational prototypes have experienced operational benefits.

The future TFM is based on the concept of operations (CONOPS), which has the goals of increased safety and improved traffic flow, and supports Free Flight concepts. This CONOPS relies on a substantial increase in data exchange and collaborative decisionmaking between NAS users (e.g., revenue carriers, business aircraft, general aviation, military, and international aviators) and FAA service providers (e.g., air traffic control and traffic flow management) and on development of improved NAS flow analysis and prediction tools.

The FAA will provide NAS users with data on the status of NAS resources and conditions, while NAS users will provide their daily operating schedules, intent, and preferences to the FAA. This data exchange is expected to improve the decisionmaking process for both FAA and NAS users. Collaboration will allow airline operators to have a much stronger voice in decisions that affect their fleet productivity rather than having those decisions imposed upon them. NAS users will be involved in collaborative decisionmaking in three ways: (1) providing real-time data to the NAS, (2) when appropriate, actively participating in flow strategy development and selection, and (3) modifying their operations to meet the collaboratively determined flow initiatives.

NAS flow analysis and prediction tools will support the collaborative development, selection, and implementation of changes in flow restrictions in the NAS. This will benefit both users and the FAA by ensuring that the NAS is operated efficiently.

20.1 TFM Architecture Evolution

Implementation of TFM services is limited by existing TFM technology, which includes hardware, operating systems, and various programming languages that have become obsolete and are unsupportable. To support current flow management capabilities and planned enhancements, the TFM infrastructure will be upgraded to an open client-server infrastructure.

The envisioned TFM capability upgrades fall into these functional areas:

- *Data Exchange:* Access to more timely and accurate information
- *Collaborative Decisionmaking:* Improved communications with users for operations negotiations
- *NAS Flow Analysis:* More automated tools to evaluate NAS status.

Specifically, these upgrades are based on the RTCA Free Flight Task Force 3 report (supplemented by Working Group 5 of RTCA Subcommittee 169), the FAA's interagency research and development plan, and the current CONOPS. The structured evolution of these capabilities is depicted in Figure 20-1. The infrastructure to support these new functions will be upgraded in a parallel effort.

The TFM architecture represents a phased approach to modernization. The approach will replace the current infrastructure (to include hardware, operating systems, program languages, and communication protocols using commercial off-the-shelf (COTS) data base management systems (DBMS) and a geographic information system (GIS)), improve current operating system functionality, improve the efficiency of existing functionality, and provide for the evolutionary implementation of new TFM capabilities. Central to the infrastructure evolution is a reengineering effort designed to provide an open-system, client-server infrastructure and modernized software architecture capable of supporting the increased functional capabilities.

The key objective of capability improvements will be incremental implementation of the high-benefit TFM capabilities as soon as possible. TFM software upgrades that are planned for the period between 1998 and 2015 are organized into four steps. Five upgrades to the TFM infrastructure are also planned for these steps. The following sections summarize the current system and the upgrades in each functional area for each step.

20.1.1 TFM Architecture Evolution—Step 1 (1998)

TMUs are located at the ATCSCC, all ARTCCs, and high-activity TRACONs. Some high-activity ATCTs have a subset of TFM functionality. Located near Washington, D.C., in Herndon, Va., the ATCSCC is a national facility dedicated to systemwide domestic and international planning and coordination. Once the sole location for traffic management activity in the NAS, the ATCSCC

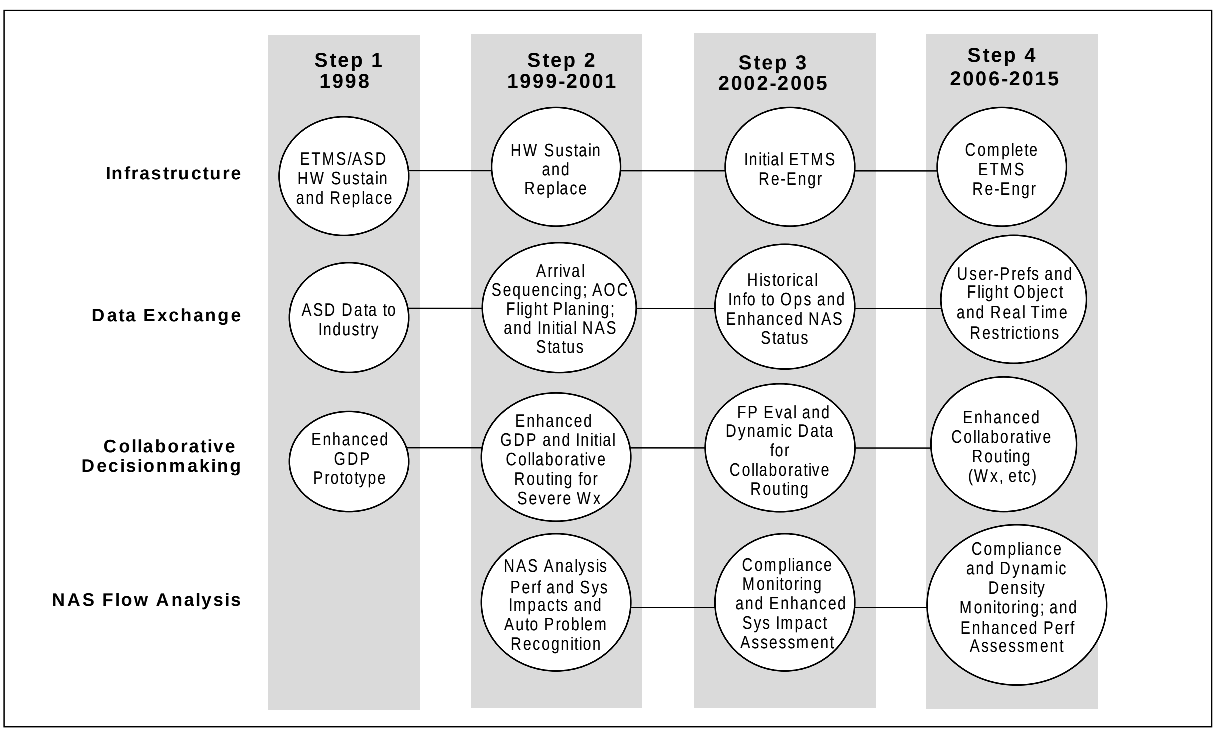

Figure 20-1. TFM Evolution

has evolved into a network of facilities with these key responsibilities:

- Monitoring air traffic and the status of airports and airspace across the NAS
- Coordinating with TMUs at local facilities to plan and implement restrictions as needed
- Assessing NAS performance and working toward long-term improvements
- Providing a central point of contact for NAS users and TMCs.

The TMSs at the ATCSCC monitor traffic, weather, resource capacity, and equipment status across the NAS to develop a systemwide perspective of NAS traffic flows and the implications of local situations (i.e., situations that affect the operations of a single en route center or a single approach control facility). TMSs are trained to work toward systemwide efficiency without allegiance to an individual en route center, approach control facility, or tower.

ARTCC and TRACON facility TMCs generally manage traffic situations affecting their airspace. They coordinate with neighboring facilities through the ATCSCC as needed and report status information to the ATCSCC. However, when traffic situations have broad impacts or when the underlying cause is extreme or long-lasting, the ATCSCC takes the lead in planning and coordination.

The ATCSCC develops flow management strategies that are implemented through the Ground Delay and Ground Stop programs, which are designed to respond to current capacity limitations due to adverse weather, runway closings, or other causes. The ATCSCC also oversees the National Route Program and monitors traffic at airports included in the Managed Arrival Reservoir program. Brief descriptions of these programs follow.

- **Ground Delay Program (GDP).** This program delays aircraft for a specific amount of time after their requested departure time in order to achieve a desired arrival rate at a destination airport. Appropriate departure delays are calculated to avoid excessive airborne holding. Controlled departure clearance times or estimated departure clearance times are assigned by a computer program at the ATCSCC, sent to host computers at the en route centers, and printed on flight strips. A prototype Ground Delay Program Enhancement system is being evaluated at the ATCSCC and selected AOCs.
- **Ground Stop Program.** This program stops all departures selected by the ATCSCC to a specific destination airport.
- **National Route Program (NRP).** This program allows flight planners to request use of specific routes in the NRP. Because the requested routes span en route center boundaries, the ATCSCC coordinates this program.
- **Managed Arrival Reservoir (MAR) Program.** For designated airports, this delay program eliminates the routine use of miles-in-trail restrictions on arrivals. The ATCSCC coordinates with local facilities to designate participating airports, and it monitors the actual use of airborne holding.

20.1.1.1 Current Infrastructure

Currently, the fundamental component of the TFM infrastructure is the Enhanced Traffic Management System (ETMS). ETMS provides a network of processors and workstations used by TMSs and TMCs to track and predict traffic flows, analyze effects of ground delays or weather delays, evaluate alternative routing strategies, and plan flow patterns.

ETMS data management and processing is centrally performed via the TFM hub. The hub is the processing engine that drives ETMS, and data provided by the TMUs are the basis for ETMS processing. The hub establishes and maintains a flight data base of active and proposed flights within the United States and adjacent oceanic air space. This data base is compiled from flight data submitted by the ARTCCs and some TRACONs and flight service stations (FSSs). Weather data, facility configuration, and facility status are maintained in separate hub data bases. ETMS has three major components:

- Applications at the ATCSCC that support national analyses
- Functions that centrally manage the ETMS wide area network (WAN) communications

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by processing and distributing messages to all sites

- Aircraft situation display (ASD) functions that support AOCs, TMUs at local facilities (ARTCCs, TRACONs, towers, and regional facilities), and other users.

The current ETMS uses Apollo/Hewlett Packard processors for TMU display functions, hub routing and message processing, and ATCSCC functions. ETMS uses a point-to-point, proprietary communications system that features centralized processing with a star topology to connect the various TFM sites. ETMS applications were developed using Apollo processors and operating systems that are obsolete and no longer supported. The ETMS hardware and operating systems currently are being upgraded, and an effort is underway to translate the applications software to C language. This effort includes defining an application interface to use the transmission control protocol/Internet protocol (TCP/IP) socket-based interface and acquisition routers supporting the transition of communications to TCP/IP, which will be accomplished in Step 2.

20.1.1.2 Current Functionality

ETMS supports TMSs in assessing traffic demand by displaying, on a national scale, traffic location and volume and predicting air traffic flow hours in advance. ETMS is a tool for dynamically analyzing projected flow into sectors and airports, enabling preventive action to ensure that controlled areas are not overloaded.

ETMS provides these functions:

- **Traffic Display.** By monitoring the ASD, TMCs can evaluate traffic flow, demand, and available capacity at the national, regional, and local levels.
- **Congestion Prediction.** TMCs can anticipate periods of congestion with the monitor alert, which compares the expected number of aircraft at specific resources (e.g., airports and sectors) against established thresholds.
- **Arrival Analysis.** When arrival demand at an airport is predicted to substantially exceed capacity for an extended period of time, the TMSs at the ATCSCC can invoke a capability to develop a GDP.

ETMS extracts official scheduled data from the Official Airline Guide (OAG) and combines the data with data in the TFM hub. Data from these sources are used to produce the ASD. The GDP is used when air traffic demand is expected to exceed the arrival capacity at an airport for an extended time period. This situation is prevented by delaying takeoffs of some of the aircraft destined for that airport. GDPs use predictions of demand and capacity to produce a schedule of departure delays.

A version of ASD is available to industry and provides a national-level aircraft situation data feed to industry, enhancing the FAA's and industry's collaborative decisionmaking.

TMSs implement cross-NAS traffic restrictions, facilitate coordination among domestic and international service providers, and interact with AOC facilities and other NAS users. The ATCSCC mission is to balance air traffic demand with system capacity. It also uses the central altitude reservation function (CARF), the special use airspace (SUA) management system (SAMS), the dynamic ocean tracking system plus (DOTS Plus), and the high-altitude route system (HARS).

CARF manages military flight plans. SAMS provides historical data of SUA usage by both military and civilian air traffic. DOTS Plus calculates preferred oceanic tracks based on current wind conditions and records the assignment of flights to tracks. HARS provides routing for military aircraft over the contiguous United States.

20.1.2 TFM Architecture Evolution—Step 2 (1999–2001)

As part of Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD), AOCs and ATM personnel will use collaborative decision-making (CDM) capabilities to enhance flight planning. The FAA will provide participating AOCs with aggregate demand lists, anticipated airport acceptance rates, arrival rates, and parameters for anticipated ground delays. In the two-way exchange of information, AOCs will respond to the FAA with flight cancellations and revised schedules.

The FFP1 CCLD capabilities to be used for TFM include:

- *Enhanced ground delay program:* Uses two-way data exchange between the FAA and AOCs to facilitate better ground delay decisions
- *NAS status information:* Provides the NAS operational status to AOCs to promote a shared understanding of NAS traffic management decisions
- *Collaborative routing:* employs electronic chalkboards to share real-time traffic flow information with users to discuss potential routing alternatives around severe weather.

AOCs and the FAA will have the opportunity to access system performance, operational benefits, and acceptability. With positive results, these CDM capabilities will be fully developed, integrated, and deployed to suitable locations.

20.1.2.1 Infrastructure Enhancements

During this period, infrastructure enhancements will include TFM sustainment (hardware and operating systems), year-2000 compliance, and hub hardware replacement. This step replaces unsupportable software and hardware components. It is a stopgap effort to pave the way for future open system enhancements. Obsolete proprietary communications will be replaced with new software and hardware supporting TCP/IP. This is an essential step that forms the foundation for the migration of TFM infrastructure and functionality to an open systems environment. Installations of ETMS at new locations (TRACONs and ATCTs) will continue (refer to Sections 21, En Route; 22, Oceanic and Offshore; and 23, Terminal). The weather and radar processor (WARP) will become the primary source of ARTCC and ATCSCC weather data and will interface with TFM decision support systems (DSSs) that require weather support. ETMS will interface with the Standard Terminal Automation Replacement System (STARS) via a one-way interface.

20.1.2.2 Functional Enhancements

Data Exchange

Data exchange enhancements planned for this step include:

- *Enhanced Data Exchange for GDP:* Will provide data exchange to support collaborative decisionmaking between the FAA and AOCs to facilitate ground delay decisions by the FAA and efficient scheduling decisions by the airlines. NAS users provide actual cancellation and delay information to the FAA. The FAA will provide aggregate demand lists, anticipated airport acceptance rates, arrival rates, and parameters for anticipated ground delays. This updated current-day schedule information will become the basis for improved GDPs and more accurate monitor and alert predictions, which will reduce adverse schedule impacts on NAS users.
- *Arrival Sequence Display, Increment 1:* Will display arrival traffic schedules in TRACON TMUs as soon as a flight is airborne. This initial increment will be directed at TRACONs with a single dominant carrier.
- *NAS Status, Increment 1:* Will provide airport-related NAS status information, which is readily available from current systems and sensors, to other FAA facilities and to NAS users. Data for major airports are expected to include current and planned airport configurations, equipment status, arrival and departure rates, and weather data.
- *AOC Flight Planning, Increment 1:* Will provide the ability to exchange additional flight planning information with AOCs. This includes sharing constraint information (e.g., airport capacity), demand projections, and user schedule updates.
- *Post-Flight NAS Analysis, Increment 1:* Will provide historical information to service providers and users for post-operations analysis and long-range planning. This initial increment addresses information that is available in current systems or with minimal data entry.

Collaboration

Collaboration enhancements planned for this step include:

- *GDP Enhancements, Increment 1:* Will provide flight schedule monitor (FSM) that evaluates users' responses to plans for GDPs. The GDP improvements in Increment 1 to be incorporated into the FSM include:
  - *Ration by schedule* uses the OAG schedule and updates from users as the basis for the

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GDP. It ensures that airlines are not penalized for exchanging real-time schedule updates with the FAA.

– *Schedule compression* improves the current substitution process to allow more flights into slots available due to cancellation, thereby compressing the overall departure schedule.

- *GDP Enhancements, Increment 2:* Will include:

  – *Flight substitution simplification* allows users to identify which flights are assigned to which arrival slots.

  – *Control by time of arrival* gives users more control over scheduling their own aircraft and managing delays en route.

- *Collaborative Routing, Increment 1:* Will provide static data for use during periods of capacity restrictions typically caused by adverse weather. Several methods will be explored that allow participants to interactively determine general rerouting of aircraft around areas experiencing unexpected disruptions.

NAS Analysis and Predictions

NAS analysis and predictions enhancements for this period will include:

- *Performance Assessment, Increment 1:* Will establish and validate the metrics for measuring real-time NAS system performance from user and service provider perspectives. The performance assessment function records, stores, manages, and facilitates access to NAS performance data.

- *Automated Problem Recognition:* Will develop an early warning capability to recognize and measure projected resource demand and inform service providers and users when capacity is projected to be exceeded. More accurate projections of resource bottlenecks can be predicted because the airlines provide timely information about current flights.

- *System Impact Assessment, Increment 1:* Will help increase the understanding of system changes by developing fast-time simulation capability, thereby allowing more timely assessment of schedule changes, flight cancellations, and other operational modifications made by decisionmakers.

20.1.3 TFM Architecture Evolution—Step 3 (2002–2005)

20.1.3.1 Infrastructure Enhancements

Throughout the evolution of the TFM infrastructure, new installations of ETMS at various TMUs and remote facilities will continue. The initial ATCSCC local information services will be available during this time period. The TFM network will begin to be converted to be compatible with local information sharing and the NAS-wide information network (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

The reengineered TFM software will provide a modern, open-system architecture that will accommodate system maintainability, expandability, and increased processing requirements. It will replace custom code with a COTS data base management system and other COTS products. It will also integrate DOTS Plus, SAMS, CARF, and other new TFM capabilities, such as GDP enhancements.

By the end of Step 3, the flight data management (FDM) prototype will be implemented at the ATCSCC and interfaced to TMU workstations at selected ARTCCs for evaluation purposes. A modernized system is essential to the timely and cost-effective implementation of the TFM functional enhancements listed below.

20.1.3.2 Functional Enhancements

Data Exchange

Data exchange enhancements planned for this period include:

- *NAS Status, Increment 2:* Will provide static and some dynamic information on current and predicted restrictions and constraints, including active SUAs, agreements between facilities about crossing altitudes and speed, miles-in-trail, resource capacities, system outages, preferred routes, and weather conditions that could affect aviation.

- *Arrival Sequence Display, Increment 2:* Will provide real-time schedule updates of departure from the gate and airborne flight information, which will improve air carriers' planning. This increment will extend the initial capability to TRACONs with two dominant air carriers.

- *Post-Flight NAS Analysis Increment 2:* Will provide historical information to service providers and users for post-operations analysis and long-range planning.
- *AOC Flight Planning Increment 2:* Will provide the ability to use additional flight planning information within FAA automation systems.
- *Two-way ETMS-STARS interface:* Will enable the display of ETMS data on terminal and tower controller workstations.

Collaboration

Collaboration enhancements planned for this period include:

- *Collaborative Routing, Increment 2:* Will provide dynamic data for use by the FAA and NAS users.
- *Flight Plan Evaluation:* Will allow users to send a flight plan to the FAA to evaluate the route, altitude, and time of flight to determine whether the planned route will violate any NAS restrictions. The user receives feedback and can request the service provider to file the flight plan at both the ATCSCC and the appropriate ARTCC. This feedback is expected to include information about system constraints and options as well as operational rationale governing the acceptance, modification, or rejection of a flight plan at the time it is filed.
- *Collaborative Routing, Increment 3:* Will address severe weather avoidance areas with suggested reroutes during periods of capacity restrictions.

NAS Analysis and Predictions

NAS analysis and predictions enhancements for this period include:

- *Compliance Monitor, Increment 1:* Will evaluate and monitor NAS user compliance with collaboratively determined TFM solutions. This capability will allow TMSs to monitor and verify that users act in accordance with ATM restrictions. Industry participants are thus assured that they are not receiving any unfair operational penalty for participating.
- *System Impact Assessment, Increment 2:* Will develop fast-time simulation capability, allowing immediate assessment (within 5 minutes) of schedule changes, flight cancellations, and other operational modifications by service providers (based on expanded flight information). This provides decisionmakers with a better understanding of the impacts of specific actions.

20.1.4 TFM Architecture Evolution—Step 4 (2006–2015)

20.1.4.1 Infrastructure Enhancements

Infrastructure enhancements to the hardware and software will provide a COTS geographic information system, which will replace custom software. This will enable external queries in support of flight objects and provide the interface to FDM systems, local TFM functionality, and integrated arrival and departure schedules. Additionally, new ETMS installations at various TMUs and remote facilities will be completed.

The hardware and software will be fully compliant with the expanded information contained in the flight object. This will support distributed management of flight planning information, active flight information, and archived information, including post-flight analysis. The TFM infrastructure and applications will be fully integrated with the NAS-wide information network.

20.1.4.2 Functional Enhancements

The flight-object structure will be in place, and AOCs and other users will begin to use 4-dimensional (longitudinal, lateral, vertical, and time) trajectory information. The information captured will be closer to real-time than in the past. Tools will be updated to take advantage of the additional information in the flight object, such as gate preferences (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing, for additional information about the flight object).

Four-dimensional trajectories will be used in planning functions for the first time during this

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period. Negotiation of a proposed flight path will take into account NAS airspace status, and the flight object will be filed and updated as changes occur during the flight. This two-way data exchange will enable improvements to both the tactical and strategic DSSs to sequence aircraft to runways closest to the airline assigned gate and allow airlines to more effectively minimize their terminal turnaround time for aircraft.

Information available to service providers (e.g., TMSs and TMCs) will be greatly enhanced: NAS users and service providers can query the flight object and receive the status of any flight in the NAS. Simulation tools will allow NAS TMSs to anticipate and react more efficiently to dynamic changes in the NAS. Flight planning activity will be enhanced with more real-time data about the NAS and active and planned flights.

Traffic flow managers and controllers will have access to the same decision tools and flight objects. These tools, with adjustments to the look-ahead time, will become density tools for assessing the ripple affect of airspace changes. Modified trajectories can be developed collaboratively with AOCs, pilots, and other NAS users. The new trajectories can then be distributed to flight decks and downstream facilities. Traffic flow managers will have access to common ATM workstations as part of the TFM DSS.

Data Exchange

The data exchange enhancement for this period includes the Arrival Schedule Tool upgrade.

- *Arrival Sequence Display, Increment 3:* Will provide data/information to the airlines suitable for displaying arrival traffic schedules and real-time updates of flight plans and subsequently to the flight object when implemented.

Collaboration

The collaboration enhancement planned for this period is:

- *Collaborative Routing, Increment 4:* Will take into account other status information of the NAS, such as equipment availability, SUA availability, when suggesting reroutes due to severe weather avoidance.

NAS Analysis and Predictions

NAS Analysis and Predictions enhancements planned for this period include:

- *Performance Assessment, Increment 2:* Will expand the Increment 1 capability to establish and validate the metrics for measuring real-time NAS system performance from a user and service provider perspective. The system performance assessment records, stores, manages, and facilitates access to NAS performance data.
- *Compliance Monitor, Increment 2:* Will enhance the previous increment to accommodate new ATM collaboration information. It will evaluate and monitor service provider and NAS user compliance with collaboratively determined TFM solutions. This capability can be used by TMSs to monitor and verify that users act in accordance with ATM restrictions that may be imposed under the Free Flight concept. Industry participants are thus assured that they are not suffering any unfair operational penalty for participating.
- *Dynamic Density Monitor:* Will determine how best to measure density, including an enhanced monitor alert algorithm to measure the current (not predictive) state of traffic density.

20.2 Summary of Capabilities

The NAS-wide information network is designed to facilitate collaboration and information sharing between users and service providers. NAS users will be involved in collaborative decisionmaking by actively participating in flow strategy development, when appropriate, and by modifying their operations to meet air traffic flow initiatives. Collaboration and information exchange will reduce operational uncertainty, improve predictability, and enhance the decisionmaking process by allowing user input into decisions that affect daily operations. Daily system performance data will be recorded to enable quantitative measurements concerning the effectiveness and efficiency of NAS operations from both the FAA and user perspectives. These capacity-related metrics will include delays, predictability, flexibility, and accessibility.

The collaborative process establishes the data exchange capability that will be used to implement ration-by-schedule procedures. The procedures modify the GDP, using the airline schedule, as defined in the OAG as the baseline for allocating actual departures and predicting arrival times, rather than the individual flight estimate. The ATCSCC consolidates the schedule information and transmits it with information on airport arrival capacity constraints.

Control by time of arrival (CTA) provides users with more flexibility in operational planning. CTA uses arrival- rather that departure-based decisionmaking procedures, giving users more control over scheduling their own flights. Users will be assigned arrival times at destination airports and will be able to determine their departure and en route schedules to meet their designated arrival times.

Military scheduling agencies will provide real-time schedules for using SUA that allow sufficient time for service providers and users to incorporate it into their planning. As a SUA's status changes, the NAS is updated in real time, and commercial flights can be routed through it.[1]

Flight plan evaluation provides NAS users with immediate feedback about system constraints and options for their planned routes. This allows users to make timely revisions before submitting a flight plan. When a flight is airborne and operational factors dictate a reroute, the collaborative flight planning process will allow real-time changes, such as reroutes around severe weather or congested airspace. The airport configuration status will include active runway, equipment outages, weather, braking action, and visibility conditions. It will also include operational data, such as arrival and departure rates and types of approaches in use. The CDM process will also give users the opportunity to take part in deciding when equipment can be shut down for routine maintenance. See Figure 20-2 for a summary of the capabilities evolution.

20.3 Human Factors

Using complex automation systems to support human activity entails a common understanding of

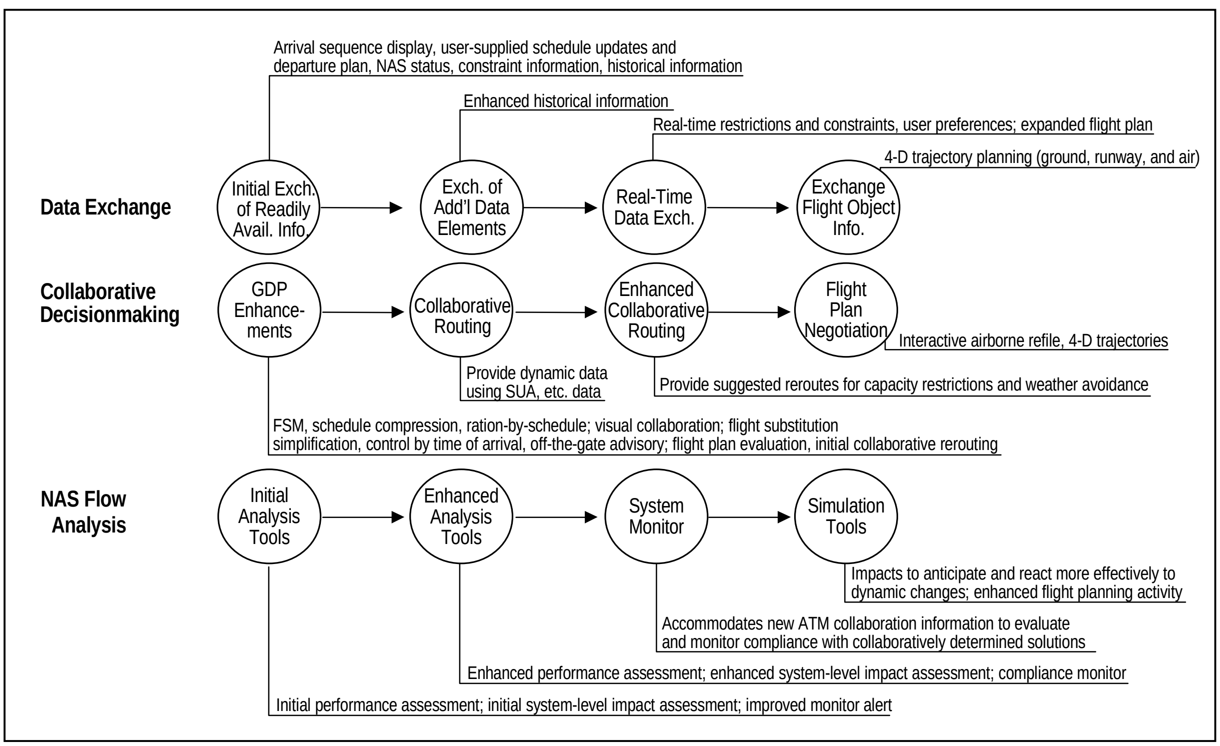

Figure 20-2. TFM Capabilities Summary

1. Generally, the SUA must be clear of commercial flights 30 minutes prior to being restricted to military operations.

intent of all the parties in the process. The collaborative decisionmaking process (already started with establishment of the airline operations center network (AOCNet) that provides information from the ASD to industry) will enable a closer coupling between AOCs and the FAA-projected traffic forecasts. This collaborative development approach ensures that both NAS users and service providers are an integral part of the design, development, and implementation of TFM capabilities. Improvements in throughput, workload, system confidence, and situational awareness will ensure that the capability will meet or exceed performance expectations.

The NAS architecture's increased level of effectiveness and efficiency of communications between service providers, facilities, and multiple users (including pilots and ground-based elements, such as AOCs) will improve the level of collaboration between parties in the system. This collaborative process involves more than just the transmittal of data across networks; it includes a coordinated understanding of the intents and motivations of the other parties. This communication, collaboration, and negotiation will be supported by various DSS tools to facilitate a rapid resolution to TFM situations. Communication methods and the information shared between parties will enhance the process of predicting the traffic flow constraints, evaluating candidate solutions, and executing the plans. The tools in place will be used by all the parties in the process and will provide for rapid and purposeful information exchange.

20.4 Transition

The transition for implementing the enhancements to the TFM Infrastructure in the three TFM functional areas is presented in Figure 20-3. The transition and the associated costs will be driven by increasing demand for the information and analytical tools necessary to implement TFM.

20.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for TFM from 1998 through 2015 are shown in constant FY98 dollars in Figure 20-4.

20.6 Watch Items

Appropriate information standards and information security must be implemented to protect sensitive and company proprietary data.

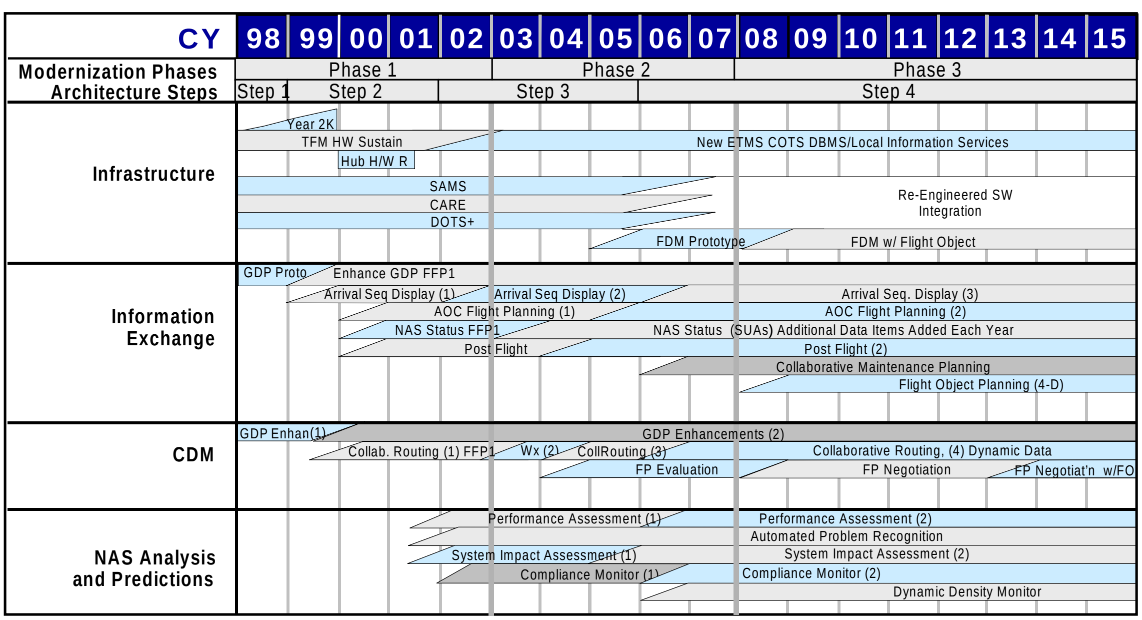

Figure 20-3. TFM Transition

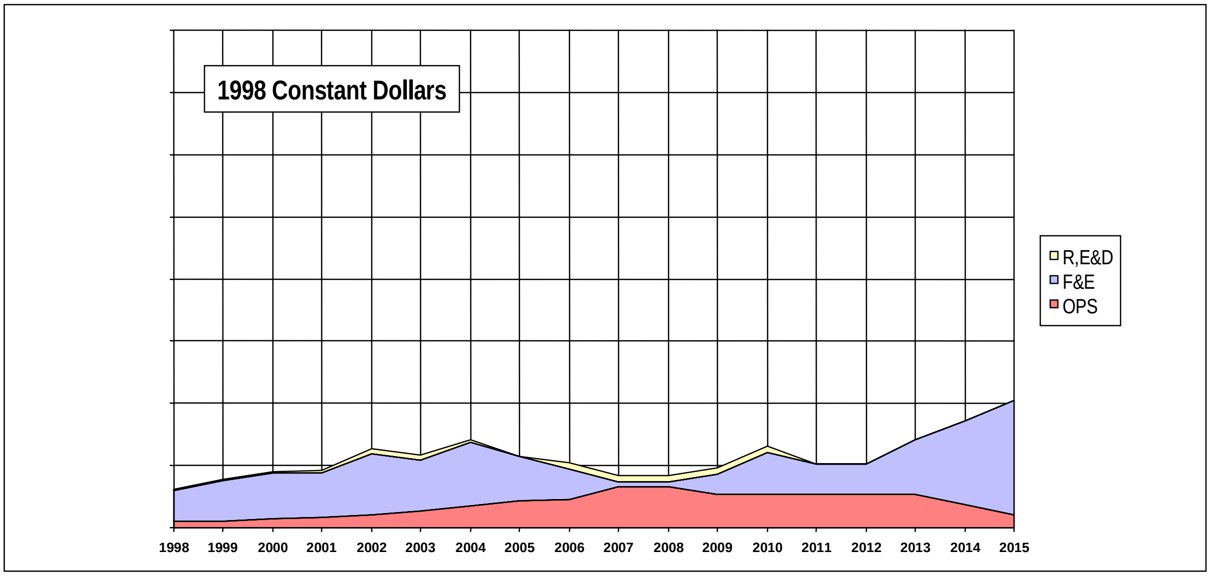

Figure 20-4. Estimated TFM Costs

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21 EN ROUTE

The En Route system is the core of information flow throughout the NAS. Air route traffic control centers (ARTCCs) are critical information hubs for the NAS. Replacing the en route infrastructure is critical to sustaining NAS services, assuring safety, and meeting user demand. The ability to sustain day-to-day NAS services takes precedence over implementing new capabilities. However, at the same time that the hardware infrastructure is being replaced to address immediate needs, it is also necessary to begin software redesign to resolve the fundamental limitations of the existing software architecture to enable the modernization needed to support user demands for additional services.

The *Government/Industry Operational Concept for the Evolution of Free Flight* defines the future operations and services for controlling aircraft in the en route domain. The operational concept focuses on an increased ability to accommodate user preferences using decision support tools for air traffic control (conflict detection, conflict resolution, sequencing to terminal, and optimal descent patterns) and traffic flow management (collaborative decisionmaking, NAS flow analysis, and data exchange).

In support of this, the en route architecture features revised flight data management (FDM), continuous access to expanded flight information (e.g., position, velocity, intended trajectory, preferences, etc.), improved decision support tools, and improved surveillance processing with more accurate position, velocity, intent, and wind information. New procedures will be developed to take advantage of the new operational capabilities. The operational concept emphasizes that the NAS will evolve to accommodate a flexible airspace structure, including dynamic airspace boundary restrictions and dynamic sectors. The en route architecture provides a basis for achieving the functionality defined in the operational concept.

The en route architecture is driven by the near-term need to sustain and then replace the en route automation hardware systems (e.g., host computer system (Host), peripheral adapter module replacement item (PAMRI), and enhanced direct access radar channel (DARC)). The en route architecture evolution provides user benefits as early as possible in support of the operational concept and the Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) plans. FFP1 is discussed in Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone.

21.1 En Route Architecture Evolution

The en route architecture seeks to sustain existing services while introducing new user services as early as practical. The first area of focus is the development of a stable hardware and systems software infrastructure with common operating systems and system services. New air traffic control (ATC) applications can then be put into place to enhance present en route capabilities.

Implementation of the en route architecture has been divided into four steps, beginning with the current operational prototypes and display upgrades and ending with enhancement and integration of the en route systems and decision support tools. An overview of the sequence and relationship of the en route functionality with respect to the en route architecture is shown in Figure 21-1. This figure and the figures for the en route architecture evolution steps show the initial operating capability (IOC) functionality. Before this deployment, extensive engineering development and integration is essential and must be funded to reduce the facilities and equipment (F&E) production procurement risks.

The first step includes replacing the Host hardware with Host/oceanic computer system replacement (HOCSR) to solve the end-of-service-life problems. It is important to note that currently, the software running on the HOSCR platform is essentially the same software architecture that was implemented in the early 1970s. The first step also includes completing the display system replacement (DSR) deployment, providing next-generation weather radar (NEXRAD) weather data to en route controllers, the prototyping efforts of center terminal radar approach control (TRACON) automation system/Traffic Management Advisor (CTAS/TMA), user request evaluation tool (URET), and the host interface device/ NAS local area network (HID/NAS LAN).

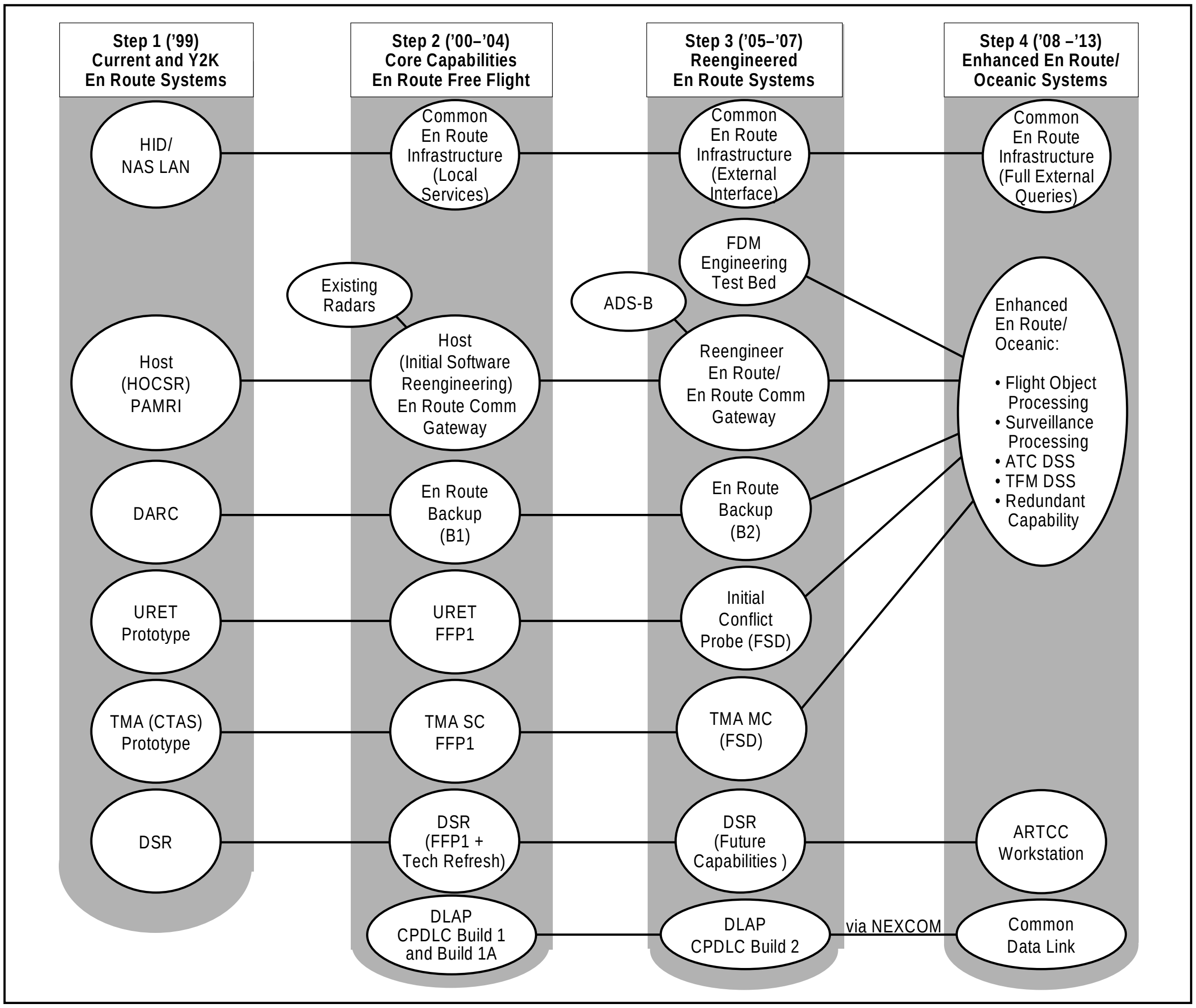

Figure 21-1. En Route Architecture Evolution

To introduce early functionality, en route capabilities will be expanded in the early stages with new applications executing on processors external to the Host/HOCSR—the first two of which will be the user request evaluation tool core capability limited deployment (URET CCLD) (evolved from the URET prototype) and TMA Single Center (SC) (evolved from the CTAS/TMA prototype).

In the second step, the en route FFP1 CCLD capabilities, (i.e., URET CCLD, TMA SC), along with controller-pilot data link communications (CPDLC) Builds 1 and 1A will be provided at selected ARTCCs. These functions are implemented on external processors and will be integrated into the core en route software architecture during the software reengineering in Steps 2 and 3. The integration will factor in lessons learned from the prototype implementations in FFP1 activities and the efforts necessary to make these products suitable for national deployment. URET CCLD implementation in FFP1 provides basic conflict probe capabilities to the en route center data-side (D-side) controllers[1] and will provide the capability for air traffic controllers to accurately predict aircraft trajectories 20 minutes ahead and identify potential conflicts. Initially, conflict probe will be implemented on a Host outboard processor at selected domestic ARTCCs and will subsequently be integrated into the coordinated ATC decision support system (DSS) tool set. TMA will acquire

1. D-side controllers assist radar-side (R-side) controllers.

flight and track data from HOCSR and calculate schedules for arriving aircraft and send them to specific TRACONs with meter lists routed to en route controller workstations.

Also in the second step, DARC and PAMRI must be replaced due to their anticipated end of service life. These replacements, along with HOCSR technology refresh, will provide platforms to be used until the enhanced en route architecture is in place. At this time, the Host software reengineering effort will also begin with surveillance processing modifications to take advantage of improved accuracy and additional information available from existing sensors and avionics. Additional modifications to integrate oceanic and en route requirements will eventually lead to common en route/oceanic processing. The reengineered Host, the replaced DARC, and the replaced PAMRI (En Route Communications Gateway) will enable radar inputs from additional terminal radar sources, which can provide additional surveillance coverage.

The evolution to the en route infrastructure begins with the DSR LAN and HID/NAS LAN and eventually results in a communications structure (i.e., the common en route infrastructure) through which all new en route functions will interface. Flight information will eventually be available to all service providers and NAS users using information services and the en route infrastructure. These information exchange services will be common with the oceanic, terminal, tower, and support facilities as described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

Concurrent with the en route functional evolution is implementation of an improved infrastructure, which is a combination of data standards, interface protocols, and a complementary suite of utility support for accessing/storing information, operating system interfacing, and translating between new and old data/interface formats. The infrastructure and services form the connectivity basis for the addition of new en route functionality into the ARTCC and for external access to ARTCC data.

Initial data link service will be introduced at one key site. Initial operational CPDLC service for non-time-critical applications will subsequently be made available nationwide. Prior to nationwide implementation, users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further deployment. Introduction of data link services will involve modifications to software and will require the addition of an outboard data link applications processor (DLAP).

During the third step, en route systems will be upgraded to accept automatic dependent surveillance (ADS) reports in addition to all of the existing sensor inputs. The position of aircraft in nonradar areas will be available to air traffic service providers through processed ADS reports. This higher level of accuracy in aircraft position and the downlinking of additional aircraft state data, such as velocity and intent, will permit enhancing decision support tools to increase system capacity and user-preferred route availability.

Step 3 will deliver aeronautical telecommunication network (ATN)-compliant CPDLC services. At each stage, these data link capabilities will be merged with new and existing ATC automation capabilities to take full advantage of the improved timeliness, reliability, and efficiency that data link services will bring to the ATC system. Eventually, the en route and oceanic data link communications and application software will be integrated into a common system.

As an expansion of the FFP1 tools, the reengineered en route system in Step 3 will contain an integrated version of conflict probe (CP) and multicenter metering with descent advisor. Part of the engineering analysis in Step 3 will be the flight data management test bed designed to prove the concept of a universal format for flight objects within en route, oceanic, and terminal domains.

In the fourth step of the en route architecture evolution, the existing functionalities that are provided by multiple systems will be replaced by an integrated en route/oceanic system developed in the previous two steps. The new concept of flight data management uses flight objects identified in the operational concept and provides electronic flight information for display to controllers. The ARTCC ATC DSS tool set is the collection, enhancement, and integration of conflict alert, conformance monitoring, conflict probe, and conflict resolution tools, which will be implemented and then enhanced.

The ARTCC ATC DSS functions support aircraft separation from other aircraft, hazardous weather, terrain obstructions, and restricted airspace. The combination of improved surveillance intent information, the tools in ARTCC ATC DSS, and the flight object in FDM will permit accommodation of user-preferred trajectories. Additionally, the ability to dynamically modify sector and center boundaries will be included to help balance controller workload.

The following sections present the en route architecture evolution in more detail. Architecture diagrams (Figures 21-2 through 21-5) show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

21.1.1 En Route Architecture Evolution—Step 1 (Current–1999)

In Step 1, the DSR program replaces the display channel complex replacements (DCCRs), computer display channels (CDCs), and plan view displays (PVDs). The HID/NAS LAN is also introduced (see Figure 21-2). Implementation of HID/NAS LAN forms a basis for adding new functionality and outboard processing (such as CP, TMA, and data link processing), allowing early delivery of new capabilities.

The Host is currently part of the primary channel ATC equipment used in the 20 domestic centers. It provides radar data processing (RDP) for center controllers and flight data processing services for center, terminal, and tower controllers.

DARC is a backup system that displays radar data and limited flight data to controllers when the primary system is down. DARC supports two modes of operation: NAS/DARC mode and DARC-only mode. In NAS/DARC mode, the Host is fully operational and provides the DARC with an interface to flight data. In DARC-only mode, flight data previously received from the Host cannot be updated, so the currentness of flight data degrades rapidly.

The Host flight data processor (FDP) defines the airspace boundaries and processes flight plans for aircraft that pass through each area, ensuring that proper routings are applied. FDP also prepares paper flight strips for the appropriate sector, terminal, and tower as the basis for coordination among adjacent NAS facilities. Flight strips are used to record information provided to an aircraft and for coordination activities.

PAMRI is an interface peripheral to the Host, providing the conduit through which the Host receives and exchanges data, primarily radar data and interfacility flight plan data.

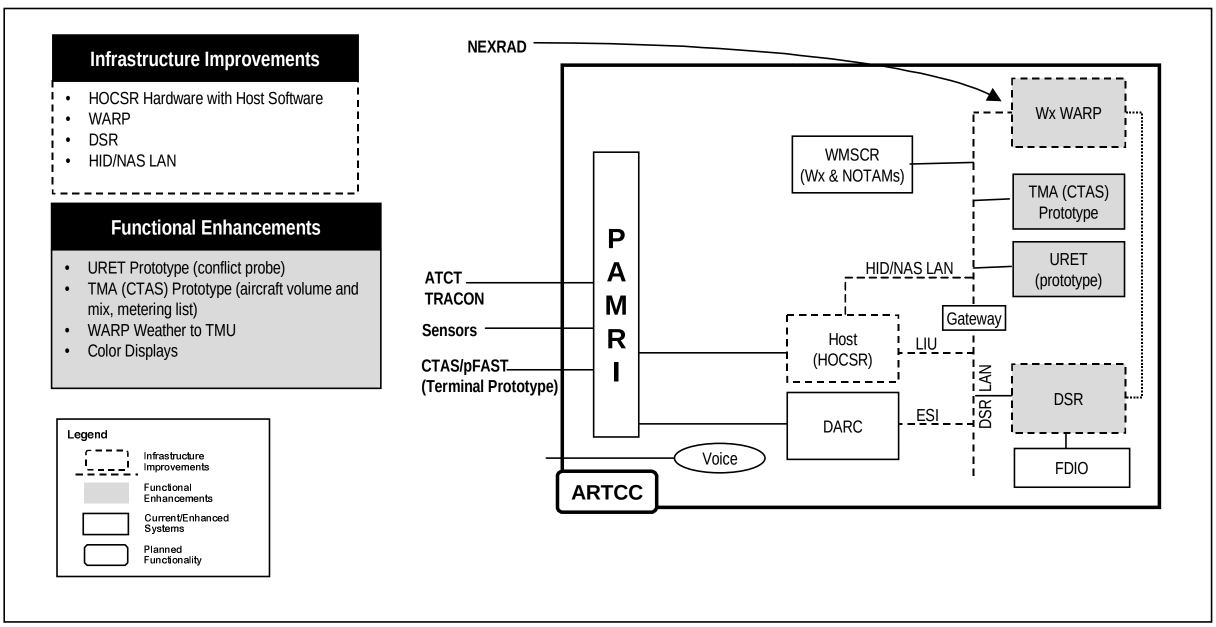

Figure 21-2. En Route Architecture Evolution—Step 1 (Current–1999)

The Host will be replaced in this step with a new platform, HOCSR, which uses the current application code with minimal modifications. Similar hardware replacement with HOCSR will be made for the oceanic display and planning system (ODAPS) (see Section 22, Oceanic and Offshore). This hardware replacement will solve the Host supportability problems.

At the Indianapolis ARTCC, a URET prototype is currently being evaluated for its ability to assist en route controllers in tactical planning to avoid potential downstream conflicts. A second URET prototype was installed in Memphis in 1997 to test conflict probes across center boundaries. Aided by forecast winds information, URET extracts real-time flight plan and tracking data from the Host, builds flight trajectories for all flights within or inbound to the center, and continuously checks for conflicts up to 20 minutes into the future. As the field trials progress, URET functionality is being displayed for use by the D-side controller. In subsequent steps, the URET CCLD FFP1 tool and full-scale development of CP will evolve from the URET prototype and the lessons learned in these field trials (see Steps 2 and 3).

The en route portion of the CTAS program includes a TMA tool for traffic managers and controllers in en route centers. This tool displays the volume and mix of aircraft destined for the entry points into the terminal area. CTAS/TMA provides miles-in-trail scheduling, time-based scheduling, and meter lists to controllers to ensure proper aircraft separation while increasing terminal capacity. This TMA function is a preproduction prototype installed at five high-capacity airports and associated ARTCCs.

HID/NAS LAN is a transitional infrastructure enhancement that will allow outboard processors for new applications to access the Host for data while minimizing use of the Host processor capacity to run the applications.

DSR provides color displays and will be delivered with new display interfaces to the Host/HOCSR. By the end of this period, DSR will display improved weather data from NEXRAD, which is processed by the weather and radar processor (WARP).

DARC, and PAMRI systems have reached the end of their service lives. Sustainment and replacement issues are discussed in the next step.

21.1.2 En Route Architecture Evolution—Step 2 (2000–2004)

In Step 2, PAMRI, and DARC functions will be sustained via replacement with modern platforms that can accommodate subsequent additions and modifications (see Figure 21-3).

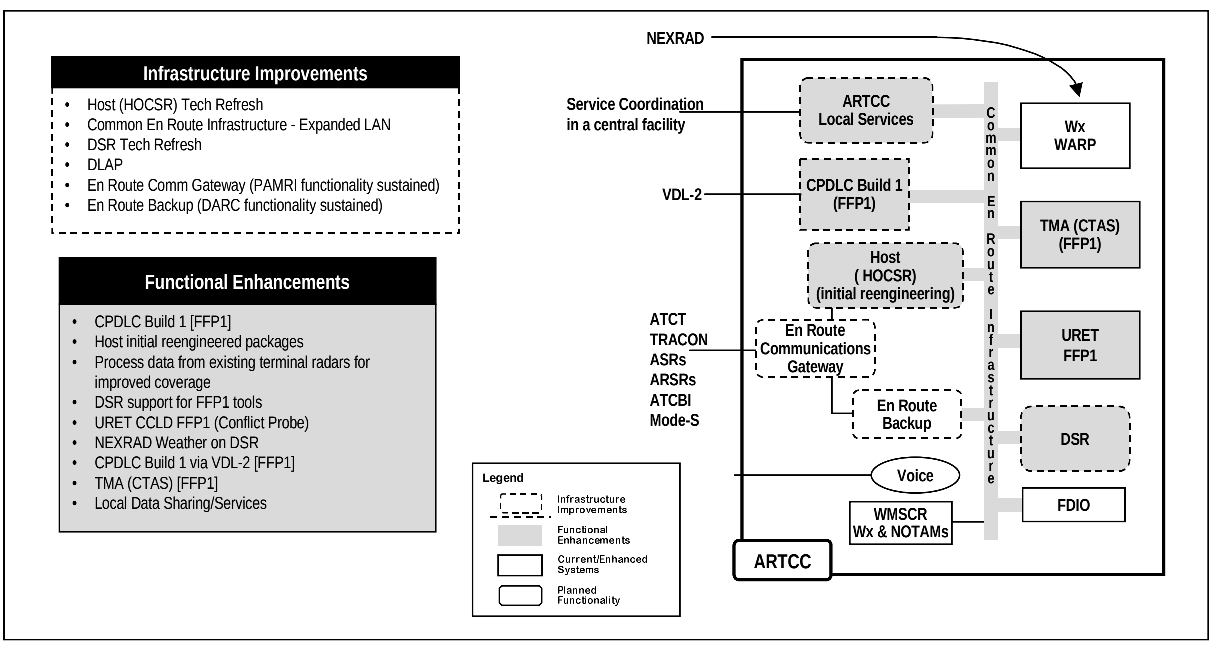

Figure 21-3. En Route Architecture Evolution—Step 2 (2000–2004)

Due to age and design characteristics, these current en route automation systems are limited in capacity and capability. They are also becoming unsupportable and limit operational flexibility within en route centers. The systems must be replaced with new systems that will support both current and future functionality and that can meet long-term availability, expandability, and efficiency requirements.

PAMRI will be replaced with the En Route Communications Gateway. It will be used in Steps 2 and 3 and will possibly be replaced for the enhanced en route/oceanic system described in Step 4. DARC will be replaced with a diverse (with respect to HOCSR) backup system, which will be used until Step 4, when a redundant capability will be incorporated in the enhanced en route/oceanic system.

URET CCLD is a limited deployment version of the functionality demonstrated in the URET prototypes and provides conflict probe core functions to selected sites identified for FFP1 CCLD capabilities. URET CCLD will use the DSR displays rather than outboard displays as in the prototype implementations. During Step 3, CP will undergo development and be deployed at all 20 domestic centers. Conflict probe functions will interface with HOCSR via HID/NAS LAN until its evolution to the common en route infrastructure.

The single center TMA tool will be implemented at selected sites for FFP1 CCLD, based on the TMA prototype described in Step 1. In future enhancements, TMA will include an improved descent advisory algorithm and time-based scheduling, and a multicenter TMA will be implemented in Step 3. Frequently, arrival streams to an airport have to be created, not only in a single en route center, but as a coordinated process with an adjacent en route center. By using aircraft track information across center boundaries, the trajectory can be modified earlier in the flight to minimize disruptions to traffic patterns while optimizing arrival rates.

Reengineering tasks will be performed to accommodate additional surveillance and communication sources and to initiate commonality with the oceanic domain. The HOCSR platform will provide the basis for developing common en route/oceanic processing. The surveillance processing in the En Route Communications Gateway and HOCSR will be reengineered to accept and process surveillance data from selected terminal radars. Additionally, these terminal sensors and many of the existing en route sensors can disseminate more accurate aircraft positional data to the automation system, as well as other valuable information that is presently not being utilized. This step will begin the process of redesigning the surveillance processing and other automation applications to make the best possible use of these sensor data. In this time frame, the complement of beacon sensors that will exist includes the monopulse ATC radar beacon system (ATCRBS) and Mode-S with ground-initiated downlink communications. It is anticipated that the addition of ADS coverage to this sensor mix will be accomplished in the next step. All terminal sensors will continue to have co-located primary radar surveillance.

The initial CPDLC Build 1 service for a limited message set, including transfer of communications (frequency change instruction), will be provided at one key site early in this step. CPDLC Build 1 is the first step toward achieving full CPDLC services. CPDLC will require software changes to the Host and DSR and the addition of an outboard DLAP. Users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further development. If results are positive, the CPDLC tool will be fully deployed nationwide. Subsequently, the initial set of non-time-critical CPDLC service will be expanded (Build 1A). These services will use more of the International Civil Aviation Organization (ICAO) CPDLC message set. Subsequent CPDLC builds will require further modifications to Host software, DSR, and DLAP.

The FAA's ground system infrastructure necessary to support these capabilities will include DLAPs located at each ARTCC to support en route and oceanic data link services and at each TRACON to support terminal and tower data link services. Each DLAP will contain the communication protocols and applications required. Initially, DLAPs will connect to communications service provider networks and later to FAA-provided networks.

The common en route infrastructure requires standards and specifications and protocols to be followed. The en route infrastructure will evolve in parallel with the infrastructure evolution of the other FAA domains (terminal, oceanic, tower, flight service) and the Air Traffic Control System Command Center. This first increment of local services and the associated infrastructure enable all intrafacility systems to share information with each other and, in future steps, to provide the means by which each facility shares data with other FAA facilities and NAS users. To achieve this, the services and infrastructure will include standards and a set of utilities for communication, data storage and retrieval, data monitoring, and recording. During Step 2, platform security will be implemented for en route computers, and the HID/NAS LAN gateways will be augmented to control access from remote systems.

21.1.3 En Route Architecture Evolution—Step 3 (2005–2007)

Reengineering surveillance processing and decision support algorithms initiated in the previous step will continue on a larger scale. Step 3 (see Figure 21-4) involves introducing new surveillance inputs, modifications to the en route communications gateway and related computer hardware, and systems software and related air traffic control decision support software algorithms.

To achieve the en route performance goals, all sensor data (e.g., data from primary radars, beacon interrogators, and dependent surveillance) will be used to the maximum. Using the Mode-S downlink capability for additional aircraft state data and the later adding of automatic dependent surveillance broadcast (ADS-B) data will both improve coverage and add to aircraft positional accuracy. These sensor data will include real-time information on aircraft velocity (airspeed, heading, windspeed, direction), acceleration (bank angle, climb rate), and intent (assigned altitude, intended waypoints). A key surveillance processing improvement will be the ability of sensors to disseminate and automation systems to accept surveillance reports in the common surveillance message format. The All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX) will provide the common surveillance message (described in Section 16, Surveillance).

Surveillance data processing (SDP) was developed to perform surveillance data fusion and reengineering of the decision support tools, which began in Step 2, and will be deployed to make maximum use of the additional data, accuracy,

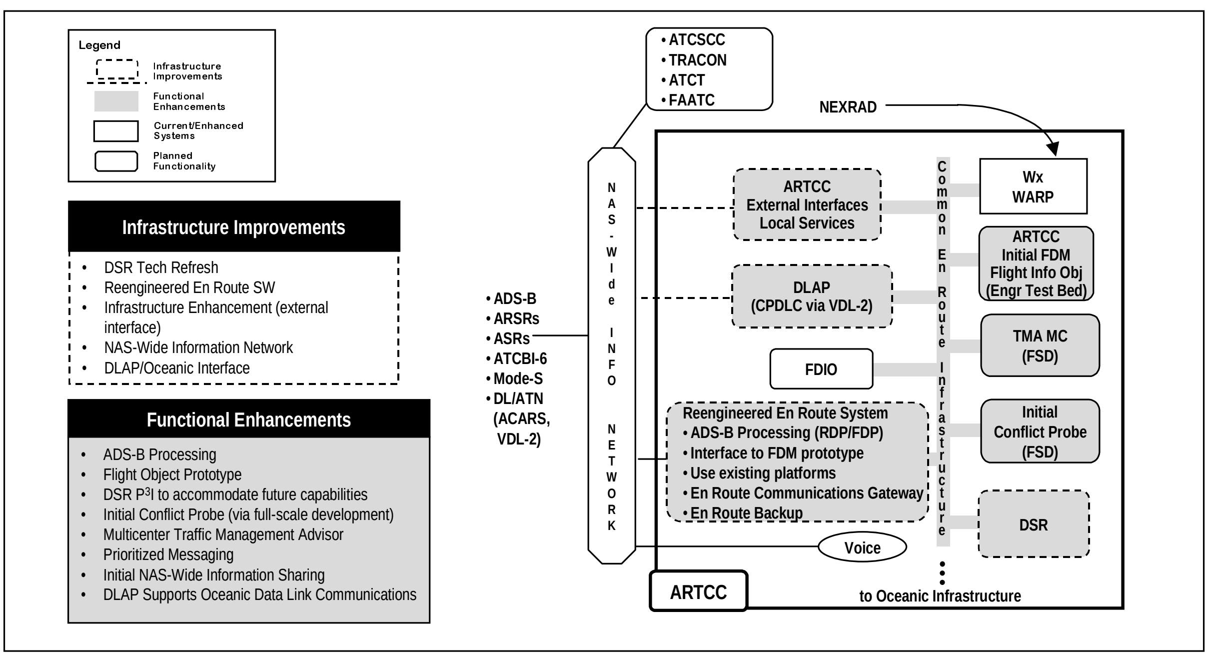

Figure 21-4. En Route Architecture Evolution–Reengineered En Route—Step 3 (2005–2007)

and update rates. These enhancements will permit increased traffic flow and allow more user preferred routes while enhancing safety.

Integrating the new data will require reengineering the en route communications gateway, the Host software, and related decision support algorithms. This is an evolutionary step leading to the en route architecture described in Step 4.

Developing and implementing a prototype FDM at selected sites is a risk-reduction strategy to verify use of flight objects and the display of additional data for ATC and user collaboration. This FDM prototype will be introduced into the en route, terminal, and oceanic domains, and it will be tested in shadow mode as an engineering test bed, in parallel with the operational FDP.

TMA SC will be expanded to include traffic management advisory capabilities across multiple en route centers (TMA Multicenter (MC)). This TMA expansion will also include improved descent advisory (DA) functionality by generating arrival clearance advisories as well as metering lists for TRACONs.

The URET CCLD FFP1 tool from Step 2 will be enhanced and deployed nationwide as CP. These enhancements will include improved computer-human interface (CHI), integration into the radar position (R-side), and other improvements.

Cutover to the next-generation air-ground communications system (NEXCOM) very high frequency digital link (VDL) Mode-3 voice operation is planned to take place in the high- and super high-altitude en route sectors.

The CPDLC message set will be expanded to approximately 100 messages (Build 2). DSR modifications will enable the en route system to display CPDLC information and new ADS-B data.

With development of the initial NAS-wide information network and common data services, applications will be able to send and receive en route information through local information exchange. This capability includes connectivity between FAA facilities as well as with NAS users through information sharing.

21.1.4 En Route Architecture Evolution—Step 4 (2008–2015)

In this step, the en route systems evolve toward a common hardware and software structure with the oceanic systems, although some applications may remain unique in each domain. The enhanced en route architecture (see Figure 21-5) implements FDM and advanced ARTCC ATC DSS tools. The need for a standard interface with NAS users drives implementation of the domain infrastructures and the local and NAS services.

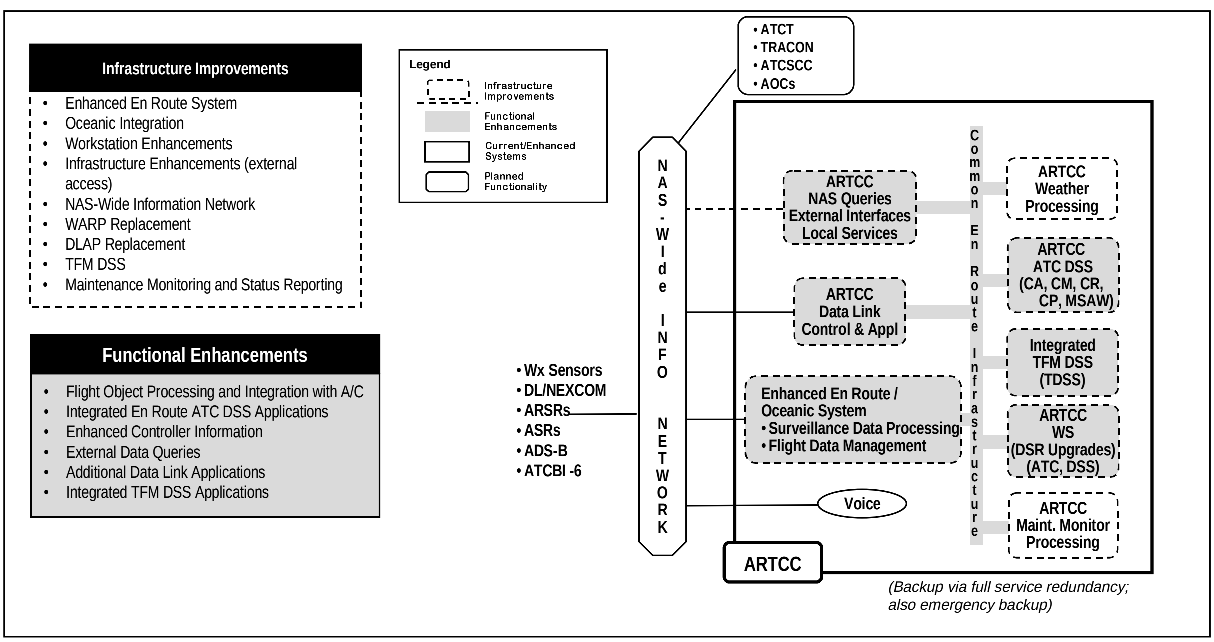

Figure 21-5. En Route Architecture Evolution–Enhanced En Route—Step 4 (2008–2015)

Surveillance processing will receive input from available sensors (e.g., primary radars, beacon interrogators, dependent surveillance), determine the position to be used for aircraft covered by multiple sensors, and provide the data (position, velocity, intent, etc.) for display and use by other DSS applications.

The replacement of FDP by FDM is driven by the operational concept approach of creating a flight object that increases the information within the flight plan and facilitates sharing of this information across domain boundaries with all authorized NAS users. In addition to expanding FDP functions in ARTCCs, the new FDM supports collaborative use at additional FAA and user facilities. The flight object contains all information about a flight (from the planning stage to the postflight archiving and analysis stages).

With FDM, flight plan processing and approval will be done nationally. Since the en route architecture is a logical architecture, the physical implementation of FDM is not implied. FDM will be implemented in a manner to prevent bottlenecks and loss of capability should one or more facilities be temporarily out of service. Each FAA air traffic facility will be capable of operating autonomously if necessary. Alternate facilities will assume FDM responsibilities in the event of an outage.

When a flight plan is activated, the flight object is retrieved and passed to the FAA ATC facilities responsible for that flight. As the flight progresses, the flight object data are automatically updated by the FDM at the controlling facility, and periodic updates are available through the NAS-wide information services for access by other FAA facilities or NAS users. FDM will archive the flight object during the flight and will maintain a permanent flight history. The content of the flight object is described further in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

The availability of improved aircraft position, velocity, intent, and wind information and the implementation of new automated decision support tools will assist controllers in separating aircraft from restricted airspace, hazardous weather, and other aircraft. It will also allow more user-preferred routes to be granted.

Full ATN-compliant CPDLC services (Build 3), including air-ground automation data exchange, will be delivered via NEXCOM. Introducing data link services will require modifications to the Host software, DSR, and DLAP. Data link via NEXCOM will provide time-critical data communications for ATC and will support collaborative planning such as user-preferred trajectories. CPDLC will support selective authentication of safety-critical messages.

Modifications to the content of and interfaces to controller displays will be required to accommodate the new integrated capabilities and flight object data. The following ARTCC ATC decision support tools will be integrated onto common platforms and the required reliability and accuracy will be maintained or improved:

- Conflict Alert
- Minimum Safe Altitude Warning
- Conflict Probe
- Weather processing interfaces to the air traffic control decision support system (ADSS)
- Conflict Resolution
- Descent Advisor
- Conformance Monitoring
- Multicenter Metering.

Additional tools will assist controllers in maintaining situational awareness and monitoring the status of airspace configuration (e.g., restricted airspace, hazardous weather location, sector boundaries). Data exchange capabilities will give service providers and NAS users an informed basis for collaboration on trajectory and strategic airspace solution planning.

Traffic flow managers and controllers will have access to the same decision tools and flight objects. These tools, with adjustments to the parameters (e.g., look-ahead time), will become density tools for assessing the ripple effect of airspace changes. Modified trajectories can be developed collaboratively with airline operation centers (AOCs), pilots, and other NAS users. The new trajectories can then be distributed to flight decks and downstream facilities. Traffic flow managers will have access to common ATM workstations as part of the TFM DSS.

Dynamic resectorization is an advanced concept that will allow ATC facilities to configure airspace boundaries in real time to accommodate varying traffic flows. ATC personnel will be able to coordinate minor sector boundary changes among themselves to reduce manual coordination and make their assigned airspace more efficient for existing traffic flow. These advanced concepts, which incorporate multiple center and sector reconfiguration capabilities, require further study to determine their feasibility.

In support of the en route enhancements, the infrastructure will provide these additional capabilities:

- Infrastructure and processing between en route and oceanic domains (New York, Oakland, and Anchorage) will be common.
- Local information service will accept and process queries from NAS users.
- Data link applications will enable common domestic and oceanic data link services.
- Automated monitoring and status reporting interfaces with NAS infrastructure management system.

The enhanced en route/oceanic architecture (see Figure 21-6) provides full ATC functionality for two physically separate, redundant systems. Each full-service system will perform all functions, interface with controller workstations, and receive data from all external systems.

An en route investment analysis will determine whether a tertiary backup system is needed to cover situations in which the primary and secondary systems both fail or are not available for some unpredictable reason. This analysis will also cover the safety implications of the various possible configurations and the impact of such issues as rapid cold start, warm start, recovery times, maintenance actions, and common-mode failures. Figure 21-6 shows a possible backup system with hardware and software diversity.

21.2 Summary of Capabilities

A stable hardware and systems software infrastructure with common operating systems and system services will be available at each step in the evolutionary system as a platform upon which ATC applications can be developed.

Initially, the en route FFP1 CCLD capabilities (URET CCLD and TMA SC), will be provided at selected ARTCCs. These functions are implemented on outboard processors, and will be subsequently integrated into the core en route software architecture during the reengineering of the host software. The integration will involve factoring in lessons learned from the prototype implementations in FFP1 activities and the efforts necessary to make these products suitable for national deployment. Figure 21-7 summarizes the capabilities evolution.

URET CCLD will allow controllers to accurately predict aircraft trajectories 20 minutes ahead and identify potential conflicts. URET CCLD will evolve to CP and be deployed nationwide. CP will be integrated into the en route automation, al-

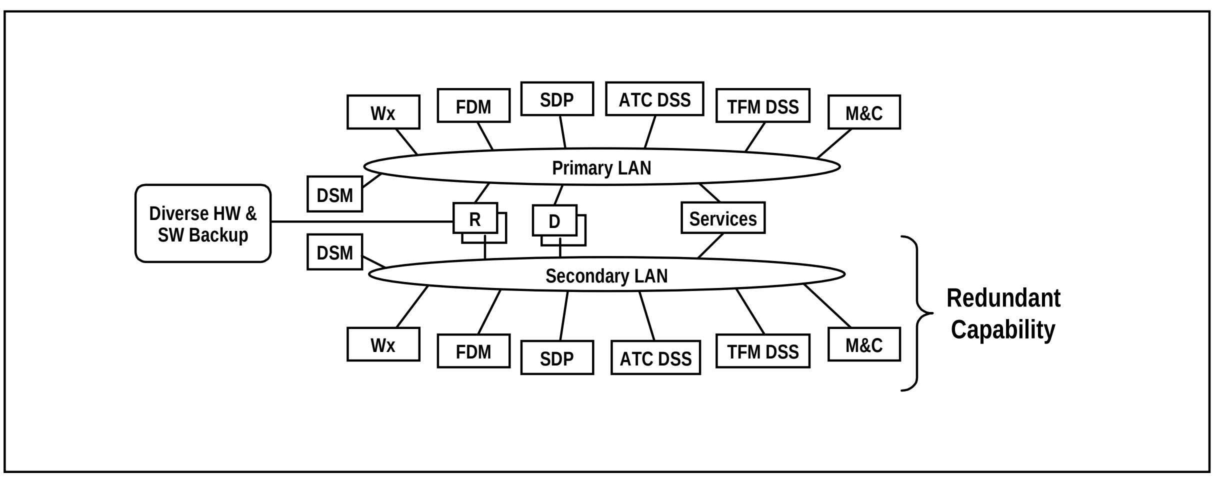

Figure 21-6. Redundant Functionality in En Route Architecture

lowing controllers to grant additional user-preferred routing.

TMA will assist controllers by calculating arrival schedules for sequencing to terminal facilities. The increased situational awareness will allow controllers to grant more user requests. TMA, which was initially deployed as a single center capability, will evolve to incorporate a multicenter capability allowing metering of aircraft to terminal areas across ARTCC boundaries.

CPDLC Build 1 will be initially installed at a single center so that controllers and pilots can gain operational experience with this capability. Subsequent national deployments will provide expanded operational information exchange by incorporating additional messages. Data link will provide additional interfaces for decision support tools as they evolve.

Implementing the flight object and the NAS-wide information services will allow data sharing across domains, facilities, and NAS users. This sharing will benefit users by enhancing the airlines planning to support daily operations. It will also improve the effectiveness of the ARTCC ATC decision support tools that provide both safety and efficiency benefits to all users.

En route automation will receive more accurate aircraft position, velocity, and intent information from both the Mode-S downlink and the ADS systems. ADS-B receives very accurate position determination from the Global Positioning System (GPS) and broadcasts aircraft information to other aircraft and ground facilities. This improved information used by enhanced DSS tools will improve en route system capacity and efficiency and may allow reduced separation standards to be implemented. Dynamic resectorization, to balance controller workload and potentially increase capacity, is a longer-term goal.

21.3 Human Factors

Implementing new hardware and software in DSSs, implementing new applications, and enabling en route technologies entails significant improvements in the way en route controllers conduct operations and provide traffic management services. Through an acquisition process that entails close collaboration with users, the resulting enhancements will provide new and different Air Traffic Service (AAT) and Airway Facilities Service (AAF) workforce tools, skills, procedures, and training. Some of the more significant increases to human-system performance include those related to:

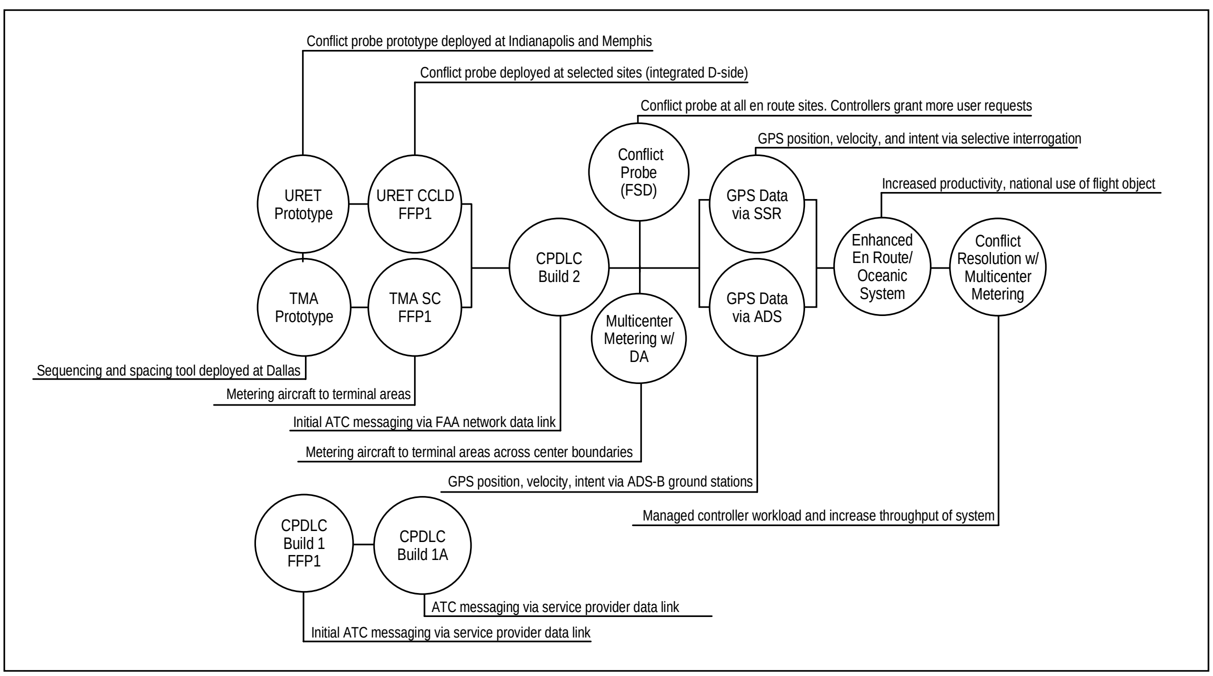

Figure 21-7. En Route Capabilities Summary

- **Information Dissemination:** Devising methods of distributing information among cooperative and collaborative en route decision-makers for such services as:
  - Advisories that inform ground and aircraft crews about alert/protected zone conditions, warnings, and resolutions
  - Common views and warnings of terrain, special use airspace (SUA), obstructions, and weather
  - Real-time reporting to users and service providers of radar, beacon, ADS, and other position information
  - Increased availability and updating of pilot intent and aircraft performance data
  - Information on integrity and timeliness needed to support flight object and DSS implementation.
- **Prototype Implementation:** Conducting the transition of prototypes for production and implementation such as:
  - Ensuring new functionality and/or CHI associated with individual prototypes or enhancements is effective and compatible (for operational/supportability) when integrated to form an evolutionary target en route baseline
  - Designing target workstations for the addition of new functionality (e.g., adequacy of the DSR data position (D-side) monitor for a conflict probe, availability of function keys on R-side, D-side, and monitoring and control (M&C) keyboards)
  - Clarifying the roles and responsibilities for new ATC applications (e.g., where DSR consoles are to be used for TMU positions).
- **Workstation Design:** Eliminating individual controller and maintenance workstation designs, divergent CHI, or incompatible CHI—especially where commercial software and application systems are prototyped and defined as independent systems that later interconnect to the Host via the HID/NAS LAN or are integrated into a single position or sector.
- **Failure Mode:** Designing (human) error-tolerant failure mode procedures, systems, and operations (under degraded or outage conditions) where there is heavy reliance on automated decision support tools for maintaining separation standards and tactical situational awareness.
- **Training and Transition:** Assessing training implications and transition requirements resulting from incremental implementation of new air traffic and airways facilities features and functionality and ATC functionalities that require significant use of common "display real estate" (e.g., tradeoffs between size of D-side glass and strip capacity).
- **Analyses:** Conducting en route analyses in support of:
  - DSR upgrades for enhanced color coding, operational display and input development (ODID) style graphical user interface, and revised CHI standard for R-side, D-side, and M&C positions
  - Baselining ARTCC en route operational and support work environments for additions to a configuration-management-controlled en route baseline
  - Design and development of a new and integrated ARTCC inventory of visual and aural alerts and alarms
  - Human factors investment analysis for the Host/DARC replacement and for en route conflict probe
  - Implementation of CHI design attribute allocation and configuration control systems.
- **Performance Measures:** Establishing objective en route measures for integrated human-system performance for such major milestones as successful completion of operational test and evaluation, initial operating capability, and operational readiness demonstration.

21.4 Transition

Figure 21-8 summarizes the en route activities transition.

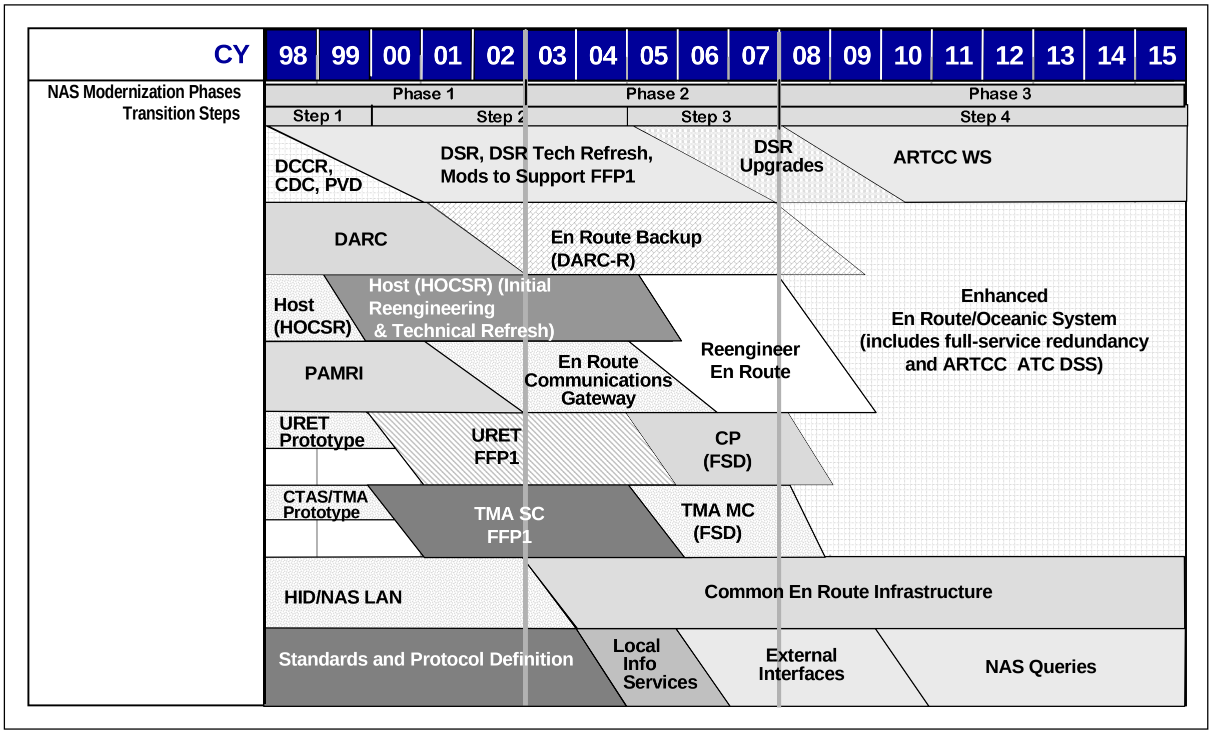

Figure 21-8. En Route Transition

21.5 Costs

The FAA's estimated costs for research, engineering, and development (R,E&D); F&E); and operations (OPS) are shown in constant FY98 dollars in Figure 21-9.

21.6 Watch Items

Achieving the en route functionality and operational benefits within the schedules and budgets described in the architecture depends upon the funding and success of the following related activities.

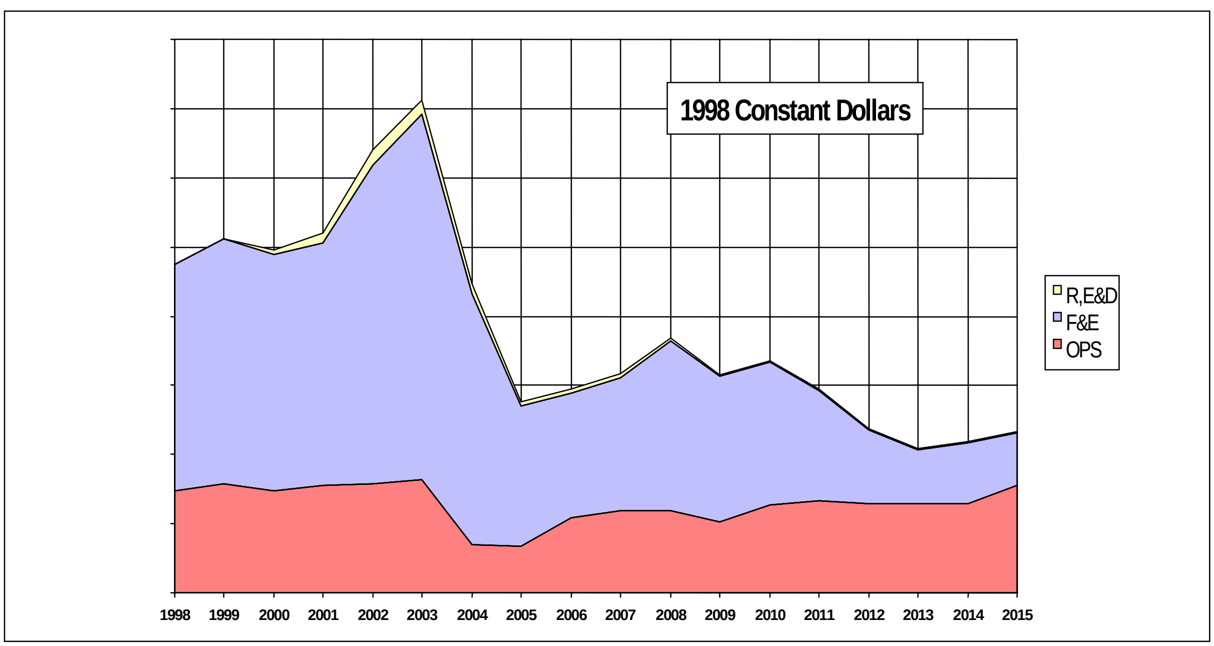

Figure 21-9. Estimated En Route Automation Costs

PART III

- Demonstrating the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS; to merge these data with radar data; and to display this information to controllers with an acceptable CHI. Results of these demonstrations would include processing algorithms and CHI standards that could then be incorporated into the en route core functionality between 2005 and 2008
- Timely deployment of the Host, DARC, and PAMRI hardware supportability solutions that solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the reengineered en route system
- Success of the FFP1 prototypes for the en route domain (URET and TMA SC) and conversion to production programs for initial conflict probe and TMA
- Transitional airspace structures and airspace redesign and their effect upon the labor-intensive effort necessary for site adaptation data maintenance. These affect both the current systems and the new decision support tools.

The budget for incorporating some of the future functionality is related to developing common algorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

- Common surveillance processing and ADS data fusion in the terminal, en route, and surface domains
- Incorporation of more accurate surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS to improve decision support tools
- Common weather services
- Common flight object processing
- Common functionality in some ATC DSS and safety-related tools.

22 OCEANIC AND OFFSHORE

The FAA is responsible for providing air traffic services to aircraft flying within specific flight information regions (FIRs). These regions include a portion of the western half of the North Atlantic Ocean, a large portion of the Arctic Ocean, and a major portion of the Pacific Ocean (see Figure 22-1). The oceanic domain consists of oceanic air route traffic control centers (ARTCCs) and offshore sites. The New York and Oakland oceanic centers are responsible for oceanic airspace, while the Anchorage ARTCC provides en route (including radar coverage) and oceanic air traffic services for all Alaskan airspace. Air traffic services provided by San Juan, Guam, and Honolulu also fall under the oceanic offshore domain. Each of these latter facilities—commonly referred to as center radar approach control (CERAP) facilities or offshore sites—is unique in terms of their air traffic control (ATC) operations and associated ATC automation systems.

The future oceanic architecture must accommodate substantial air traffic growth that is expected in oceanic and offshore airspace through automation enhancements and procedural changes. These changes will reduce separation standards—longitudinally, laterally, and vertically. The *Strategic Plan for Oceanic Airspace Enhancements and Separation Reductions*, June 1998, describes the FAA's strategy to support the overall oceanic air traffic management (ATM) system improvement concept, including separation reduction and other airspace enhancements. A combination of ground and airborne automation capabilities and technologies in satellite-based communications, navigation, and surveillance will reduce or balance controller workloads to help oceanic service providers solve potential conflicts, traffic congestion, and demand for user-preferred trajectories. This architecture is centered around improving automation and communications capabilities in the ground system to take advantage of communications, navigation, and surveillance capabilities in aircraft avionics. A major goal of the architecture is to lower training, operations, and maintenance costs by evolving toward maximum commonality between offshore, oceanic, and domestic air traffic services.

Figure 22-2 shows that the oceanic ATC services of Oakland, Anchorage, and New York will evolve toward commonality with the en route domain, while Guam, Honolulu, and San Juan will evolve toward commonality with the terminal domain. The concept of commonality is that applications software will be common, where appropriate, but will also incorporate the domain-specific capabilities necessary for operational suitability.

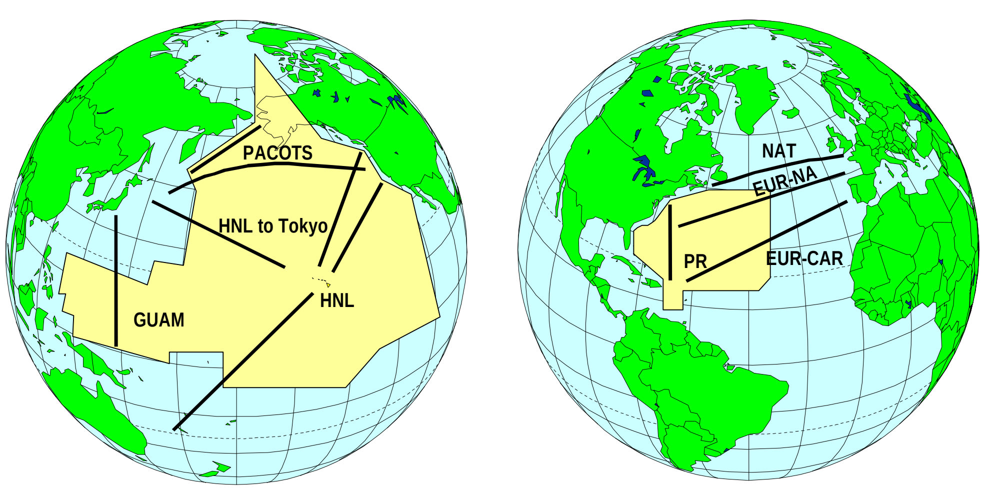

Figure 22-1. Oceanic Airspace

Oceanic airspace is an area in which airspace users can realize significant benefits from enhanced ATC system capabilities. Small improvements in fuel efficiency or reductions in flight times can create large savings in airline operating costs. Predictability of aircraft getting and staying on their preferred routing can be especially cost beneficial for the airlines.

22.1 Oceanic Architecture Evolution

Technical advances in automation and in satellite communications and navigation can increase user flexibility while increasing levels of capacity and safety in the oceanic and offshore domain. Automatic dependent surveillance (ADS), better navigation tools, near real-time communications, and automated data exchange between pilots and oceanic air traffic controllers via data link will provide the flexibility to change flight trajectories in response to changes in wind-optimal routes, rather than having to adhere to predefined routes that are calculated hours in advance. Oceanic service providers will have situation displays of traffic in oceanic airspace and decision support system (DSS) tools, allowing them to provide procedural separation from their displays at reduced separation minima.

Pilots will have a cockpit display of nearby traffic received via automatic dependent surveillance broadcast (ADS-B) from other aircraft. Pilots and service providers will be able to initiate and exchange data link messages via satellite communications (SATCOM) or high frequency data link (HFDL). Pilots will be able to negotiate climbs, descents, and specified maneuvers between affected aircraft and the oceanic service provider (see Section 16, Surveillance, and Section 17, Communications). Decision support tools will be used to help oceanic service providers detect and resolve possible conflicts and to prevent controlled aircraft from entering restricted airspace.

The role of oceanic service providers will evolve from performing procedural separation using paper strips to performing procedural separation employing situation displays and controller decision support system tools for separation and strategic planning.

The oceanic architecture will evolve through four steps leading toward commonality with the en route and terminal architectures. The evolution of the oceanic and offshore systems toward a common infrastructure will require close coordination with the acquisition efforts of other domains. These dependencies are discussed in the specific architectural steps. The applications software will become as common with other domains as appropriate. Domain unique requirements, primarily due to surveillance and communication differences, will be retained as necessary for operational suitability.

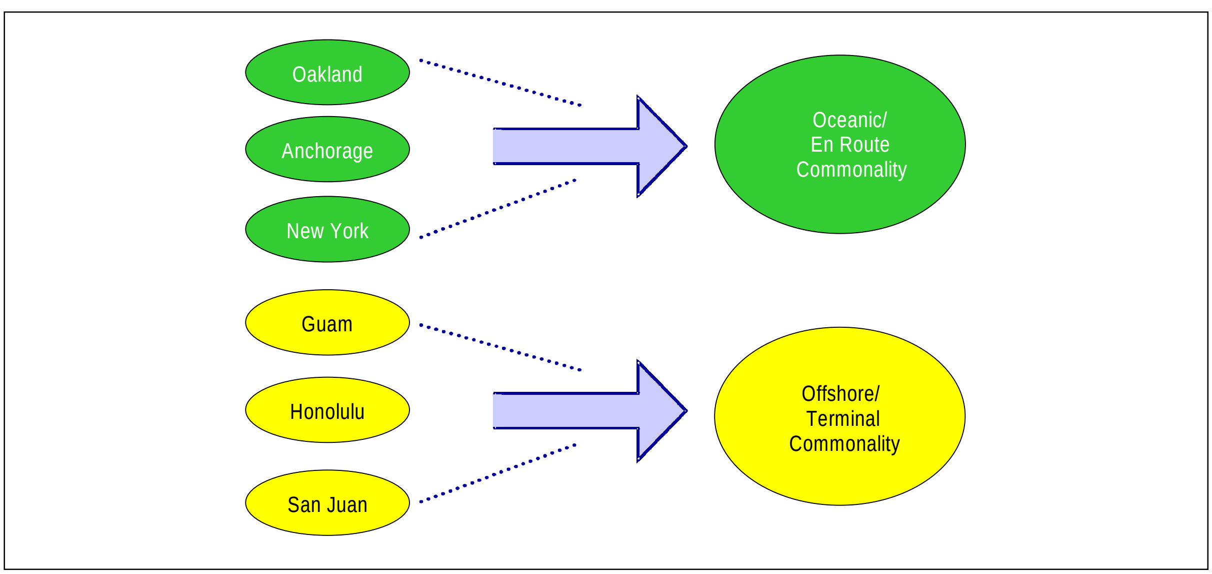

Figure 22-2. Oceanic Architecture Evolution Toward Commonality

The oceanic architecture is driven by the availability of enabling capabilities. The timing of specific capabilities is presented in Table 22-1. The table focuses on the evolutionary steps of the oceanic architecture. Table 22-2 presents the evolution of the concept of operations (CONOPS) in terms of the types of events experienced by users and oceanic ATC service providers for a typical oceanic flight in relation to the evolution of the NAS.

The oceanic architecture evolution is organized into two elements: oceanic and offshore sites. These sites include:

- New York and Oakland, which are oceanic FIRs, are discussed in Section 22.1.1, Oceanic Architecture Evolution.
- Anchorage, Guam, Honolulu, and San Juan are offshore sites and are discussed in Section 22.1.2, Offshore Architecture Evolution.

22.1.1 Oceanic Architecture Evolution

Currently, a number of innovative alternatives to meet oceanic user needs and commitments are being evaluated. This process could substantially affect the architectural evolution.

The architecture diagrams presented later in this section show the content of each evolutionary

Table 22-1. Oceanic Capabilities Evolution

	1998 Current	1999–2007 Steps 2 and 3	2008–2013 Step 4
Communications	HF voice through communications service provider Some FANS-1 data link	HF voice through communications service provider Direct communications FANS-1 data link (SATCOM) Some ATN Some HFDL	Rarely HF voice via communications service provider Some FANS-1 data link (SATCOM) Some HFDL Mostly ATN
Surveillance	Pilot position reports	Pilot position reports (voice or data) ADS-A ADS-B (air-air)	Some pilot position reports (voice or data) ADS–A ADS-B (air-air)
Navigation	RNP 10 Northern Pacific	RNP-10	RNP-4
Separation Standards	60-100 nmi long/lat 2,000 ft vertical 50 lateral nmi In-trail climb, descents RVSM Atlantic	50 nmi lateral leading to 50/50 nmi RVSM expanded to other areas Limited self-separation procedures	Additional self-separation procedures (Shared separation responsibility) RVSM
Airspace Structure	Fixed Flexible Random	Less fixed More flexible More Random	Random User-preferred profiles
Interfacility Comm	Voice Teletype NAS-to-NAS Initial AIDC	Voice Teletype NAS-to-NAS Data (e.g., AIDC)	Mostly data (e.g., AIDC) Some voice Some teletype NAS-wide information network
User/ATM interactions	User files flight plan User and TFM negotiate oceanic fix crossing time	Defines flexible tracks International collaboration for dynamic changes DARP reroutes	NAS-wide information network further facilitates new system applications
TFM	Defines flexible tracks Assigns fix crossing times	Defines flexible tracks International collaboration for dynamic changes DARP reroutes	Defines corridors
Airborne Equipment	Airborne collision avoidance system	Airborne collision avoidance system CDTI Cockpit multifunctional display (e.g., weather, etc.)	Airborne collision avoidance system CDTI Enhanced cockpit multifunctional display Additional applications

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Table 22-2. Evolution of Events in Oceanic Domain

	1998 Current	1999–2007 Steps 2 and 3	2008–2013 Step 4
Users	For non-west coast flights with no gateway reservation, flights enter oceanic airspace at lower than preferred altitude or are delayed due to 10 or more minutes longitudinal separation required Uses HF voice communications via communications service provider (e.g., ARINC) Some FANS-1/A data link communications Reroute requests are time-consuming for pilot Pilot sees some traffic on TCAS display, most traffic out of range Pilots report waypoint position reports Few self-separation procedures (in-trail climb/descent)	For equipped aircraft, communication going from domestic to oceanic is seamless (both using data link) For some FIRs, seamless interfacility transition May request more reroutes (less workload intensive for pilot) CDTI displays more traffic, and ADS-B provides additional information ADS-A-equipped aircraft automatically sends waypoint and periodic position reports Limited self-separation procedures using ADS-B (air-air) and CDTI (in-trail stationkeeping, lead climb/descent)	Communications going from domestic to oceanic ATC seamless (mostly ATN) Seamless interfacility transition No need to request for reroute as long as maneuvers are within the corridor Pilot sees more traffic and weather information Able to fly preferred profile with shared separation responsibility
Service Providers	Altitude requests granted, if controller is not busy Ignores altitude profile information in flight plan; controller does not offer altitude change unless requested by aircraft or needed to resolve problem Reroute requests time-consuming for controller, limiting ability to grant requests Receives waypoint position reports from pilot Voice or teletype interface with other FIRs Prototype AIDC for limited data interface with other FIRs	Controller uses altitude profile information in flight plan for planning purposes Altitude requests more likely granted due to additional airspace available (e.g., RVSM), altitude profile information in flight plan, and controller less busy with manual tasks Reroute requests are more likely granted (less workload-intensive for controller) Receives ADS-A waypoint and periodic position reports from aircraft More data interface with other FIRs Automated decision support tools (including conflict probe) reduce reliance on paper strips	Few pilot position reports. Receives ADS-A position reports Flight Progress monitoring by exception Data communications interface with all other FIRs Flight Object processing facilitates handling change requests

step in a logical or functional representation, without any intention of implying a physical design or solution. An overview of the sequence and relationship of the oceanic functionality with respect to the oceanic architecture is shown in Figure 22-3.

22.1.1.1 Oceanic Architecture Evolution—Step 1 (Current–1999)

Current oceanic ATC systems at New York and Oakland do not rely on radar coverage. Operations are performed through procedural separation using paper flight strips. Air-ground communication is indirect through a third-party, high frequency (HF) radio operator. Since direct radar surveillance is not possible over most of the ocean, aircraft report their positions to oceanic ATC at prescribed intervals or locations as they progress along their flight paths. Navigation is performed principally with onboard inertial navigation systems (INS) and communication by HF voice. To allow for INS errors and communications uncertainties (e.g., atmospheric disturbances, indirect voice relayed through a third party and language problems), current oceanic separation minima are very large. Intensive coordination is required to ensure accurate communications between FIRs via teletype or telephone.

In the New York and Oakland centers, the Oceanic Display and Planning System (ODAPS) provides a situation display of aircraft positions based on extrapolation of periodic HF voice position reports and filed flight plans. ODAPS software was originally derived from the flight data processing software used by the en route Host computer system (HCS) and modified to meet oceanic-unique requirements. ODAPS also supports a procedural conflict probe capability. The ODAPS interim situation display (ISD) is currently used by service providers for planning and situational awareness. ISD does not yet provide the controller decision support tools required for it to be the primary means for procedural separation.

Oakland is currently using a limited version of oceanic data link (ODL) in a single sector. Oakland and New York sites have a telecommunica-

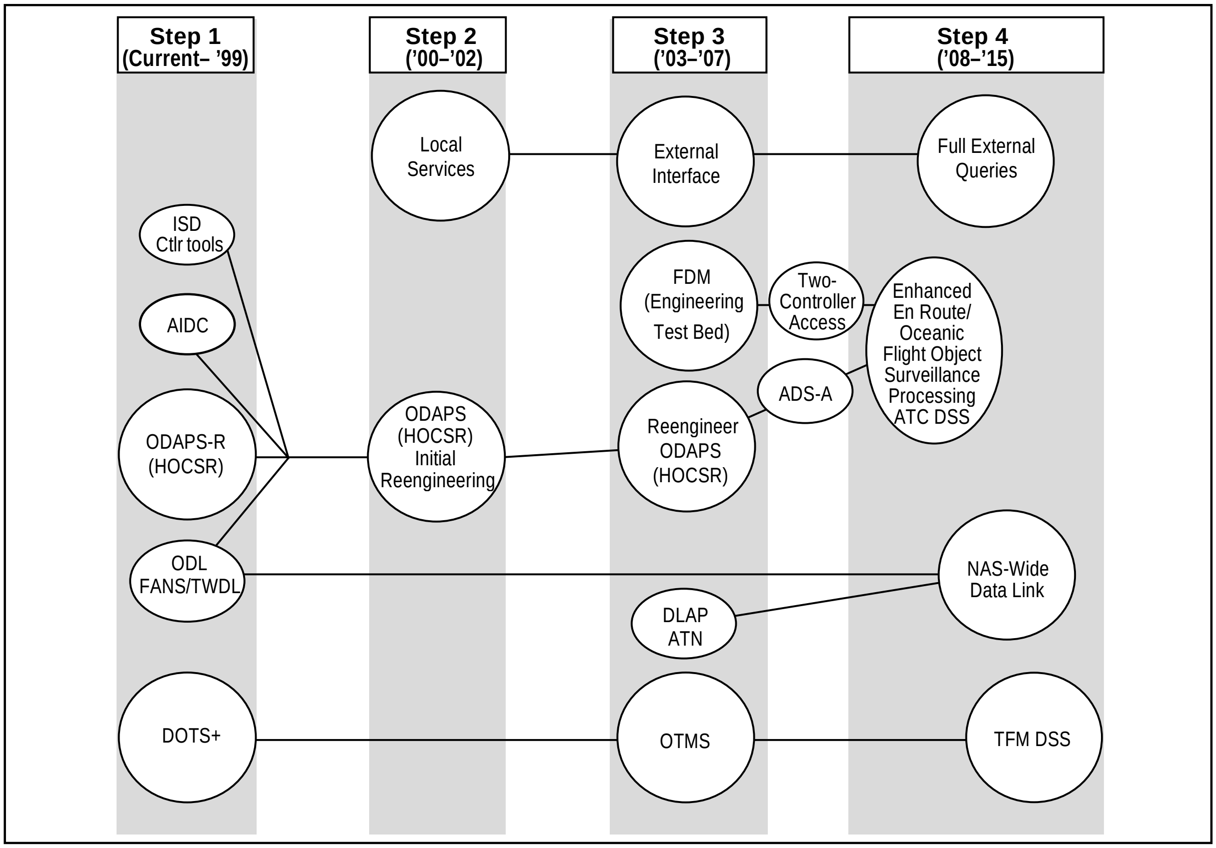

Figure 22-3. Overall Oceanic Architecture Evolution

tions processor (TP) that enables each sector controller to retain and search through ODAPS messages and messages received from the ARINC radio operators. The current oceanic workstations include an ISD and a TP/ODL prototype workstation that displays flight information. In addition, New York is using an air traffic services interfacility data communications (AIDC) prototype providing ground-ground data link between selected FIRs.

The oceanic centers also use the dynamic ocean track system (DOTS Plus) as a traffic management planning tool. DOTS Plus identifies optimal tracks based on favorable wind and temperature conditions, while projecting aircraft movement to identify airspace competition and availability.

An operational, procedural-based conflict probe will support reduced vertical separation minima (RVSM) and 50 nmi lateral through ODAPS. RVSM reduces vertical separation from 2,000 feet to 1,000 feet for aircraft in specified segments of oceanic airspace. Oakland implemented procedural changes to support 50 nmi lateral separation for properly equipped aircraft and for required navigation performance (RNP)-10 aircraft in the North Pacific Ocean. Procedural changes and international coordination will enable RVSM to be extended to the entire Pacific Ocean for equipped aircraft. This step also brings enhancements to DOTS Plus. Figure 22-4 illustrates the logical oceanic architecture during Step 1.

Enhancements to the oceanic architecture during Step 1 include:

- Procedural-based conflict probe checks oceanic flight plans and proposed revisions for potential conflicts and provide an alert if separation minima are predicted to be violated.
- DOTS Plus improvements include hardware replacement and functional enhancements, such as improved weather data, elimination of duplicate message feeds, track definition message interface to ISD, remote monitoring and software maintenance, and an enhanced graphic user interface (GUI). DOTS Plus expands upon the previous DOTS track genera-

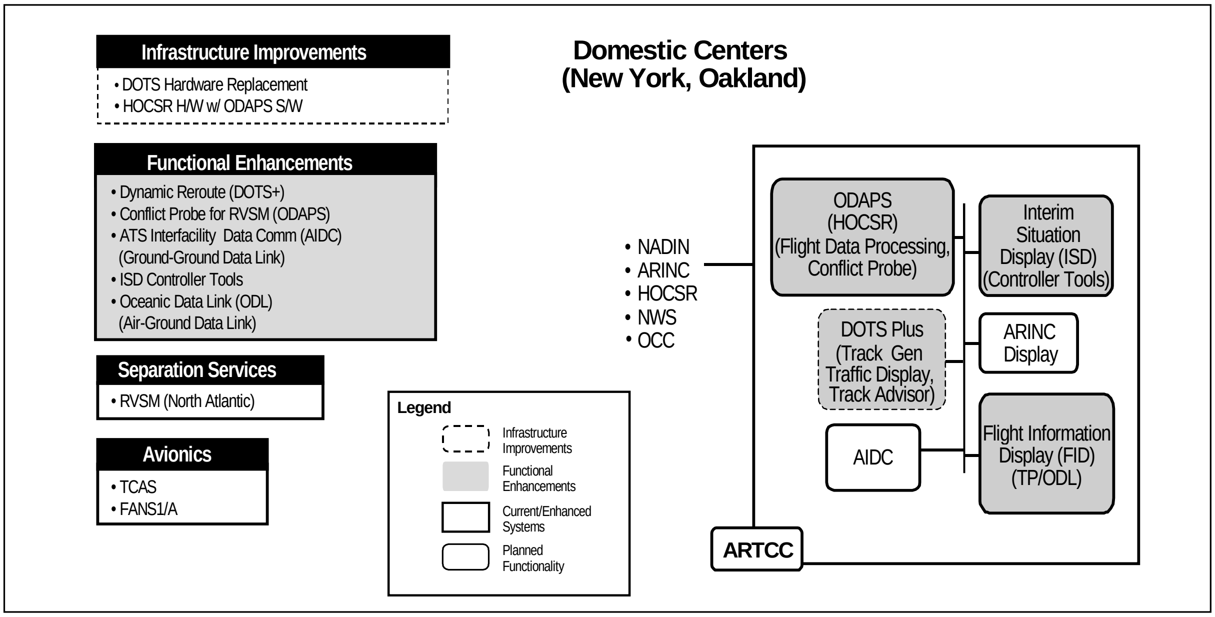

Figure 22-4. Oceanic Architecture Evolution—Step 1 (Current–1999)

tion, traffic display, and track advisor functions and is capable of supporting flexible tracks and dynamic reroutes. DOTS Plus enhancements streamline the process accounting for weather and balancing loads, and allow the tracks to be updated more rapidly.

- Multisector ODL supports air-ground data link communications and extend single-sector data link functionality to all ODAPS sector positions. In this early phase, ODL windows are displayed to the oceanic service provider on the flight information display (FID). However, if ODL is not running, the FID displays telecommunications processor data. This multi-sector ODL capability, via ARINC as a data communications service provider, uses satellite communications for exchanging messages with FANS-equipped aircraft. Data link functions include automated entry of flight identification into a list of flights entering the sector, a display of messages to the track control position, and a transfer-of-communication message to aircraft exiting the FIR.

- Initial AIDC supports the ground-ground data link communications, which enables message/coordination to be exchanged between U.S. oceanic FIRs and their equipped, adjacent FIRS.

- The ISD tool set introduces automated decision support tools to the controller for calculating time, speed, and distance for head-on, in-trail, and crossing situations.

- The ODAPS hardware will be replaced to solve end-of-life-cycle and year 2000 problems. The en route program, Host/oceanic computer system replacement (HOCSR), will replace the en route and oceanic hardware. The current oceanic functionality will be sustained using the existing ODAPS software on the same hardware platform that is being used for the en route automation system. The economies of scale enabled by using common hardware for oceanic and en route applications will result in lower life-cycle costs. Moving to a common hardware platform will also provide a starting point for the evolution to a common software architecture to support oceanic and domestic ATC applications, as discussed in Section 21, En Route.

RVSM (North Atlantic) enables properly equipped aircraft to be cleared closer to their optimum altitudes and to be closer to the wind-optimal routes. Conflict probe helps enable conflict-free clearances and provides additional flexibility in granting user-requested routings in a timely manner. DOTS Plus provides flexible tracks, enabling the system to be more responsive to changing wind conditions.

Improved air-ground communications and coordination (enabled by ODL) will reduce the miscommunications inherent in messages relayed by voice. Data link and expanded radio coverage will provide direct pilot-controller communications, enabling more timely delivery of clearances by the oceanic service provider and responses from the flight deck. The AIDC will make similar improvements in ground-ground communications.

The ISD controller tools will provide oceanic service providers with further automation support, reducing the amount of time required by manually intensive computations. Along with conflict probe, these capabilities enable service providers to identify potential conflicts and to grant user-preferred routings and requests more frequently.

22.1.1.2 Oceanic Architecture Evolution—Step 2 (2000–2002)

In Step 2, the Oakland and New York centers will refresh the oceanic flight data processing (FDP) hardware. Additionally, reengineering tasks will begin to accommodate additional surveillance and communication sources and to initiate commonality with the en route domain. The HOCSR platform will provide the basis for developing common en route/oceanic processing. Procedural changes and international coordination will enable RVSM to be extended to the Pacific Ocean for equipped aircraft.

Figure 22-5 illustrates the logical oceanic architecture during Step 2.

22.1.1.3 Oceanic Architecture Evolution—Step 3 (2003–2007)

In Step 3, the Oakland and New York centers will incorporate the expanded AIDC message set and automatic dependent surveillance addressable (ADS-A). Figure 22-6 illustrates the logical oceanic architecture during Step 3.

Step 3 enhancements are outlined as follows:

- The expanded AIDC message set will allow oceanic service providers to send, receive, and display additional ground-ground data link messages between FIRs (i.e., coordination; transfer of communications; and emergency, miscellaneous, and general information messages).
- A two-controller access program will provide a fully functional oceanic data link position for an assistant controller in each sector, allowing shared sector responsibilities. The ODL windows will be displayed on both the FID and ISD and will be accessible from either position.
- A full-fidelity trainer will enable oceanic service providers to train in a realistic system simulation environment.
- ADS-A will enable FANS-equipped aircraft to automatically provide periodic position re-

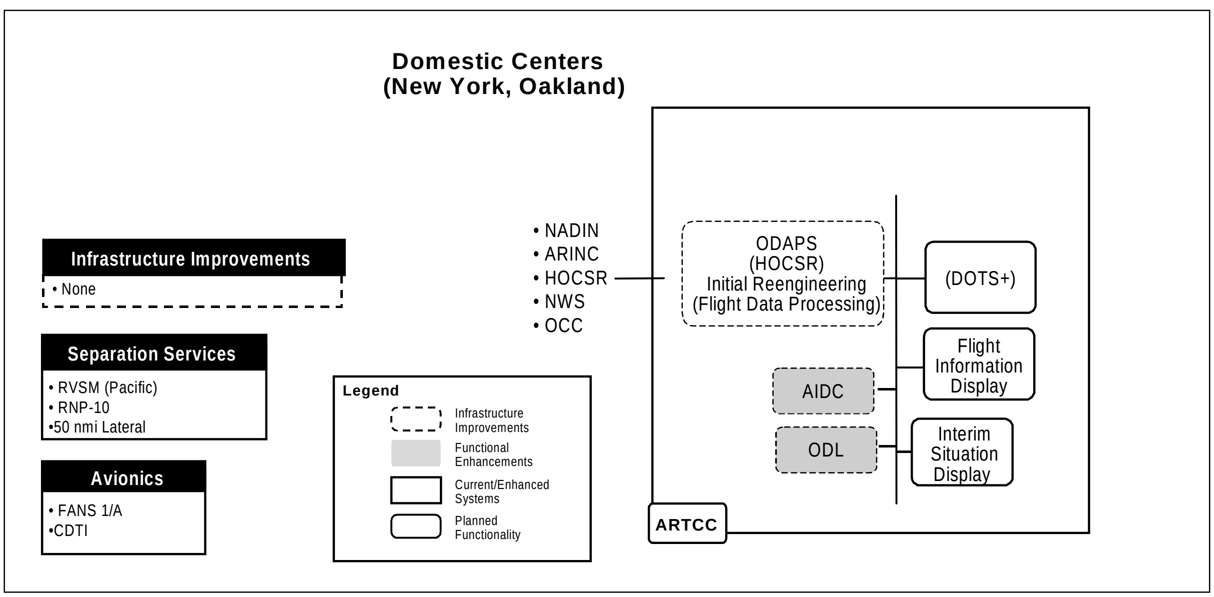

Figure 22-5. Oceanic Architecture Evolution—Step 2 (2000–2002)

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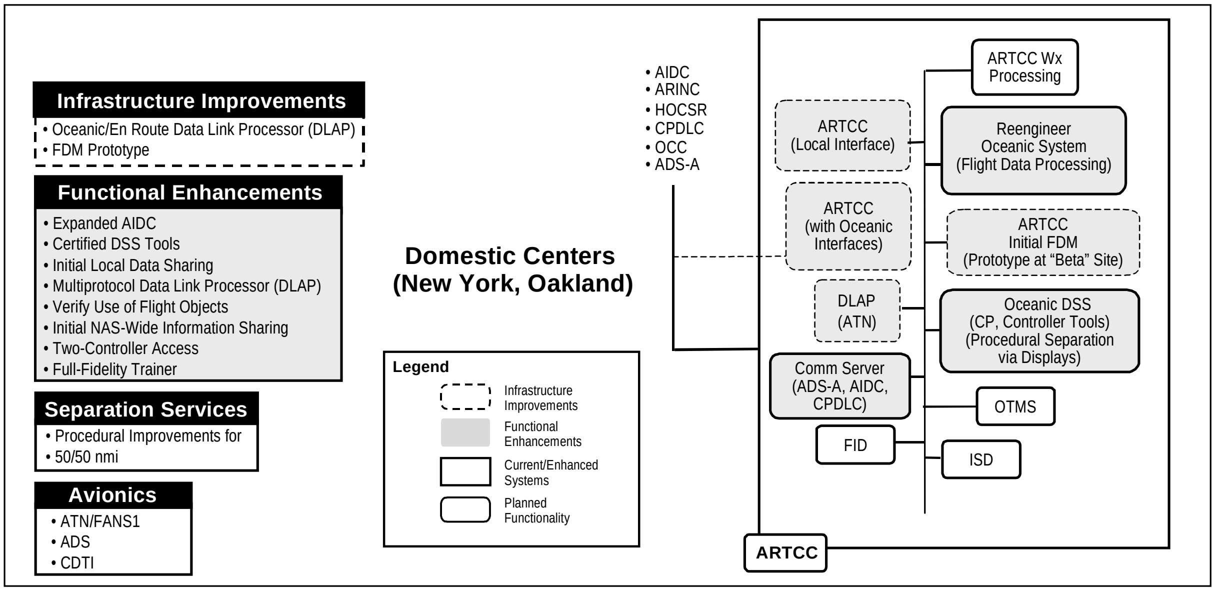

Figure 22-6. Oceanic Architecture Evolution—Step 3 (2003–2007)

ports and event waypoint reports via data link. ADS-A will also include lateral deviation event reports. The waypoint position report will be relayed to oceanic service providers for processing. The oceanic automation will display and update the aircraft position accordingly. ADS-A will support automation functionality that provides distance checking for 50-nmi longitudinal separations, sends distance checking alerts to both the FID and the ISD, and updates to the oceanic flight plan data base. ADS-A position reports will be used by conflict probe in its computations. A common server will support ODL, AIDC, and ADS-B.

- The oceanic architecture allows horizontal separation standards to be reduced to 50/50 nmi, enabling more aircraft to get closer to their wind-optimal routes. Increased frequency and accuracy (GPS-based) of position reports, combined with better controller-pilot communications, helps enable reduced separation standards without adversely affecting safety. ODL, high frequency data link (HFDL), and ADS-A will enable improved ground-air communications and more reliable and frequent surveillance data. DOTS Plus will be renamed the Oceanic Traffic Management System (OTMS) to reflect its expanded scope. The interface between the OTMS and the enhanced traffic management system (ETMS) will help improve coordination between oceanic and domestic traffic flow planning.

- The en route software reengineering efforts will accelerate in Step 3 to address domestic and oceanic commonality (see Section 21, En Route, for a detailed description).

- Ground automation upgrades to display supplementary flight data lists, along with accompanying procedural changes and approved DSS tools, will enable the elimination of paper flight strips.

Figure 22-6 shows the implementation of local information services at Oakland and New York Centers that will incorporate oceanic-unique applications.

A flight data management (FDM) prototype will be deployed at one ARTCC. When the FDM is operational, it will replace the existing flight data processing capability. The FDM prototype will be run in parallel with the existing FDP and serve as an engineering test bed. The FDM expands the existing ODAPS FDP capabilities by enabling the processing of the flight object (see Section 19). This development will enable implementation of a common FDM to support all domains. In brief, a flight object will contain information about a flight (planning through post-flight archiving and analysis) and will be accessible to all FAA service providers and authorized NAS users.

FANS-1/A two-way data link (TWDL) communications, ADS-A, and Air Traffic Services (ATS) facilities notification services will be provided and, as user equipage and demand dictate, ATN controller-pilot data link communications (CPDLC) will be provided. At this time, some oceanic and en route data link processing capabilities will be merged in the Data Link Applications Processor (DLAP). With the initiation of an oceanic communications interface into DLAP, ATN services can begin to be supported in oceanic airspace via DLAP. Aircraft equipped with data link applications, such as TWDL/CPDLC, will be flying in domestic en route airspace, as well as oceanic. Much of the communications software (e.g., FANS-1/A, ATN) needed for the ground systems will be common to both domains.

DLAP will provide multi-protocol and multi-application support for data link communications to aircraft flying in both oceanic and en route airspace. DLAP will mask the application differences from aircraft with different types of data link equipage and will present data link messages to the oceanic automation system in one common format for each application. The oceanic systems, therefore, will only have to include one version of each application (TWDL, ADS-A, and ATN), even though multiple airborne versions of each application are being supported.

Two-controller access provides oceanic controllers with the capability to more evenly distribute the workload associated with reducing separation minima and handling data-link-equipped aircraft during peak-traffic times. The transition to "stripless" operations and the corresponding reduction in controller workload will enable oceanic service providers to meet expected increases in demand. Service providers will use visual displays and decision support tools to monitor the traffic situation and to separate traffic. They will do more strategic planning and grant more user preferences and requests. During this time frame, additional procedural improvements will be considered to allow limited self-separation procedures, such as in-trail station-keeping and lead climb/descent.

The expanded AIDC message set will provide improved coordination between the oceanic facilities and other international FIRs. The data link support for both FANS and ATN will take advantage of improved avionics and significantly improve ground-air communications. The common oceanic en route data link platform will facilitate seamless aircraft transitions and data transfers between the two domains.

22.1.1.4 Oceanic Architecture Evolution—Step 4 (2008 and Beyond)

Figure 22-7 illustrates the logical oceanic architecture in this step. The evolution of oceanic and offshore systems to a common hardware and soft-

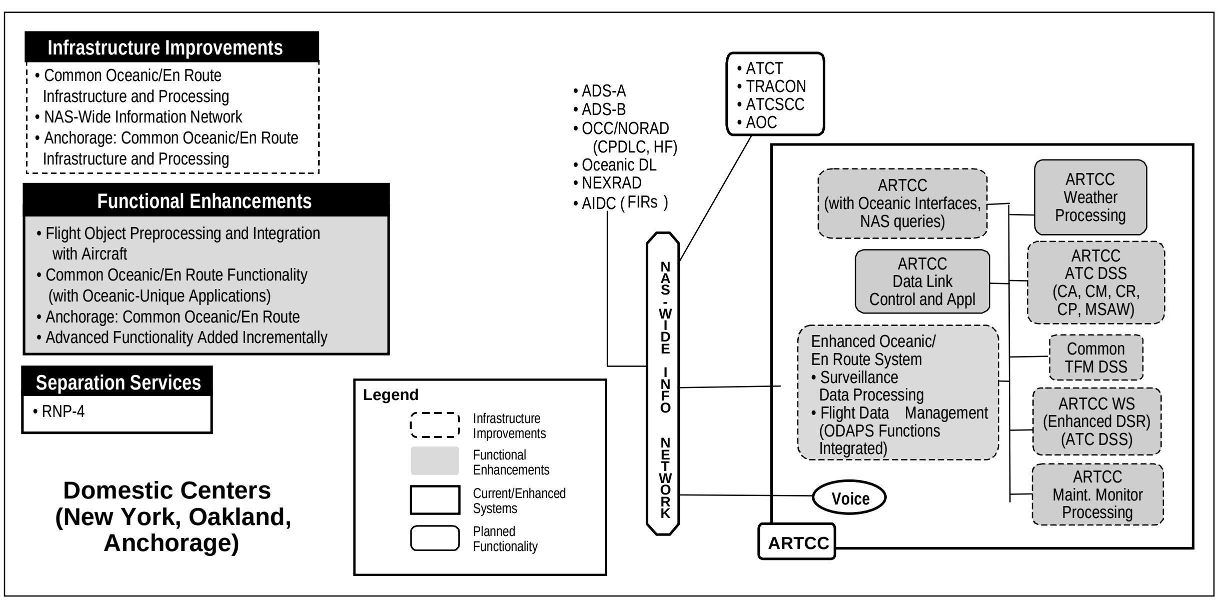

Figure 22-7. Oceanic Architecture Evolution—Step 4 (2008 and Beyond)

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ware infrastructure with en route and terminal will be completed in Step 4. Oceanic operations at the Oakland, New York, and Anchorage centers will depend on the acquisition of the common enhanced oceanic en route system. An FDM will be implemented at all three sites, replacing the existing FDP. A common surveillance data processor for the en route, oceanic, and terminal domains will be implemented at each site with domain-specific modifications. The ISD and FID functionality will be integrated into the enhanced DSR workstation, which becomes the common ARTCC workstation. It is assumed that the enhancements made to the DSR during Step 3 of the en route architecture evolution will enable it to support oceanic requirements. A common ARTCC infrastructure will support common and unique oceanic and en route enhanced weather, decision support system, and maintenance applications. This common, modern infrastructure will provide the ground-based platform needed for developing many of the advanced functional enhancements (see Section 21, En Route).

Oceanic communications will continue to migrate from voice communications to data communications. While data communications becomes the primary means of communications, oceanic will continue to support a mixed equipage environment. Increased use of ADS, CPDLC, and AIDC will continue to reduce the need for manual coordination. The ability to communicate trajectory and route information (via CPDLC or TWDL) will enable increased granting of user-preferred routes. ADS-A will be integrated with an advanced conflict probe tool tailored for oceanic use. (see Section 17, Communications).

The NAS-wide information network will be structured to conform to NAS-wide data standards; to incorporate multilevel access control and data partitioning; to provide data security and allow real-time data access via queries; and to assume all data-routing and distribution functions, including data link. Planned functional enhancements, added incrementally to the system, may be able to support even further reductions in separation standards. These would include advanced functionalities, such as dynamic sector boundaries, conflict resolution, and 4-dimensional trajectories.

Expanded collaborative decisionmaking would enable further sharing of separation responsibility between the oceanic service provider and the flight crew. The pilot's ability to support climbs, descents, and crossing and merging routes will be supplemented by uplinked conflict probe information and display of more traffic and weather data. The oceanic service provider's ability to predict conflicts will be supplemented by pilot-intent information downlinked from the aircraft. Common TFM decision support tools will further improve coordination between oceanic and domestic facilities.

The full NAS-wide information network implementation will provide a uniform data format between oceanic and the en route and terminal systems. The ICAO message set will be supported and data communications interfaces will exist with all other equipped FIRs. Data link communications will be standardized, resulting in improved coordination and seamless interfacility transitions.

22.1.2 Offshore Architecture Evolution

The current offshore oceanic ATC systems in Anchorage, Honolulu, San Juan, and Guam have partial radar coverage. The Anchorage and Honolulu TRACONs are not part of this domain and are discussed as part of the terminal architecture. The offshore facilities use the Microprocessor En Route Automated Radar Tracking System (MicroEARTS) for radar data processing of domestic and oceanic traffic wherever radar surveillance is available. The MicroEARTS are automated primary and beacon radar tracking and display systems whose functional capabilities are essentially the same as the terminal area ARTS IIIA radar data processing system, with the additional capability of employing both short- and long-range radar.

Table 22-3, Offshore Evolution Events, summarizes the major events that will occur at each offshore site as it evolves toward commonality with either the en route or terminal domain.

The following paragraphs present the offshore architecture evolution in more detail. Architecture diagrams show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

Table 22-3. Offshore Evolution Events

Step	Anchorage	Honolulu	San Juan	Guam
1. (1998–1999)	DOTS+ H/W replacement DOTS+ functionality CPDLC MicroEARTS	OFDPS-R (HOCSR) with OFDPS software MicroEARTS	Current system (Miami patch) MicroEARTS RDP	Current system (Manual FDP) MicroEARTS RDP
2. (2000–2004)	OCS rehost/replacement MicroEARTS upgrade DSR workstation ARTCC local information services ADS and data fusion	Additional HOCSR STARS/P³I Terminal controller workstation Terminal local information services ADS and data fusion	Terminal controller workstation Local information services ADS and data fusion	STARS/P³I
3. (2005–2007)	ARTCC local information services upgrade NAS-wide information network	Local information services upgrade NAS-wide information network SDP	STARS/P³I Local information services upgrade SDP NAS-wide information network	Terminal controller workstation ADS and data fusion Local information services upgrade SDP NAS-wide information network
4. (2008 and beyond)	Common infrastructure with en route	Common infrastructure with terminal	Common infrastructure with terminal	Common infrastructure with terminal

22.1.2.1 Offshore Architecture Evolution—Step 1 (Current–1999)

Figure 22-8 depicts Step 1 of the offshore architecture for the four offshore sites: Anchorage, Honolulu, San Juan, and Guam.

Anchorage

Anchorage uses a unique flight data processing system—the offshore computer system (OCS). OCS processes oceanic flight data and implements its own version of data link for FANS-equipped aircraft in Anchorage ARTCC airspace, including offshore and oceanic sectors. OCS also provides flight data to the MicroEARTS radar data processor. An existing AIDC prototype system will become operational to support a ground-ground data link with other international FIRs. The sector layout at Anchorage will also include a DSR workstation that is connected to the MicroEARTS, which will replace the current radar display. While Anchorage will be using the DSR common console hardware (driven by the MicroEARTS and the OCS), it will not be using the DSR software.

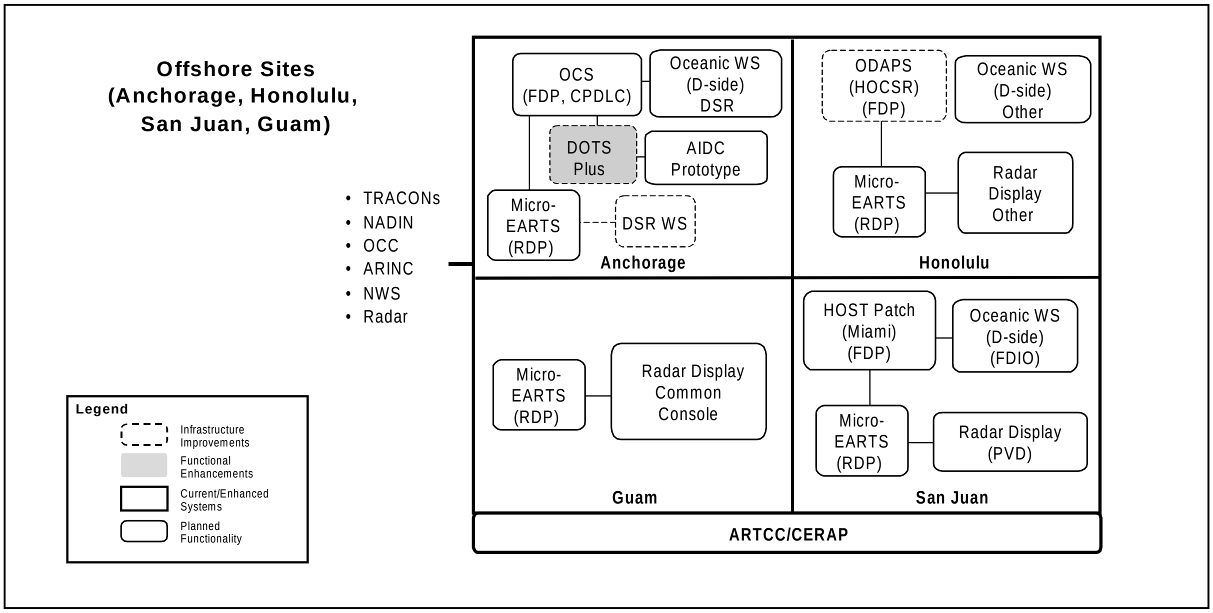

Figure 22-8. Offshore Architecture Evolution—Step 1 (Current–1999)

Anchorage (like New York and Oakland) also has the automated planning tool, DOTS Plus. DOTS Plus implements track generation and track advisor functions and interfaces with the National Airspace Data Interchange Network (NADIN) for the exchange of track information and aircraft position reports. Scheduled DOTS Plus improvements include hardware replacement and functional enhancements, such as improved weather data, elimination of duplicate message feeds, remote monitoring and software maintenance, and an enhanced GUI.

Anchorage implemented procedures to support reduction to 50 nmi lateral separation for RNP-10 aircraft in the North Pacific Ocean (NOPAC) in April 1998.

Honolulu

In Honolulu, the CERAP uses the Offshore Flight Data Processing System (OFDPS), which is based on modified ODAPS software and is interfaced to a MicroEARTS radar data processor. An OFDPS communications system provides a channel for external interfaces to communicate with OFDPS. The MicroEARTS system, commissioned in January 1998, provides new controller workstations. The OFDPS will be rehosted as part of the En Route HOCSR program, so the HOCSR hardware will be using existing OFDPS application software during this period. (See Section 21, En Route).

San Juan

In San Juan, the CERAP obtains flight data information remotely from the Miami ARTCC (Miami patch), which is transmitted to the replacement flight data printers (RFDPs). San Juan uses the plan view display (PVD) for MicroEARTS controller positions. San Juan commissioned the MicroEARTS system in early 1998.

Guam

Guam currently uses MicroEARTS with common consoles that function as situation displays at each sector. (MicroEARTS was commissioned in March 1997.) Flight plans are received over an aeronautical fixed telecommunications network (AFTN) circuit, and flight strips are printed using a PC-based program. All flight plans are manually entered into MicroEARTS, and all flight data processing is done manually by the controllers. No new improvements are scheduled prior to Step 2.

22.1.2.2 Offshore Architecture Evolution—Step 2 (2000-2004)

Figure 22-9 depicts Step 2 of the offshore architecture for the four offshore sites.

Anchorage

Due to aging equipment, the OCS will be rehosted (OCS-R) onto a more modern platform that includes a reengineered flight data processor that is based upon the existing OCS software. MicroEARTS functionality may be upgraded with ADS-A, ADS-B, data fusion, and improved weather data as a part of the Safe Flight 21 and Capstone demonstration programs. This ADS-B and data fusion capability will be needed to support objectives of these programs. Information sharing will be implemented via the initial ARTCC local information services and will incorporate unique local interfaces.

Honolulu

An additional HOCSR will be deployed to support the transition from the CERAP's present Diamond Head location. The existing HOCSR will be maintained as a backup during the transition period. After the relocation, the MicroEARTS will be replaced by STARS and terminal controller workstations. The STARS functionality will be upgraded to coincide with the STARS preplanned product improvements (P^3I) (see Section 23, Terminal). Information sharing will be implemented via the initial local information services and will incorporate unique local interfaces.

San Juan

The Miami patch for the San Juan FDP process will remain unchanged during this period. Information sharing will be implemented via the local information service and will incorporate unique local interfaces.

Guam

The STARS with the terminal controller workstations will replace the existing MicroEARTS system and common consoles. The STARS functionality will be upgraded to coincide with the STARS P^3I (see Section 23, Terminal). Infor-

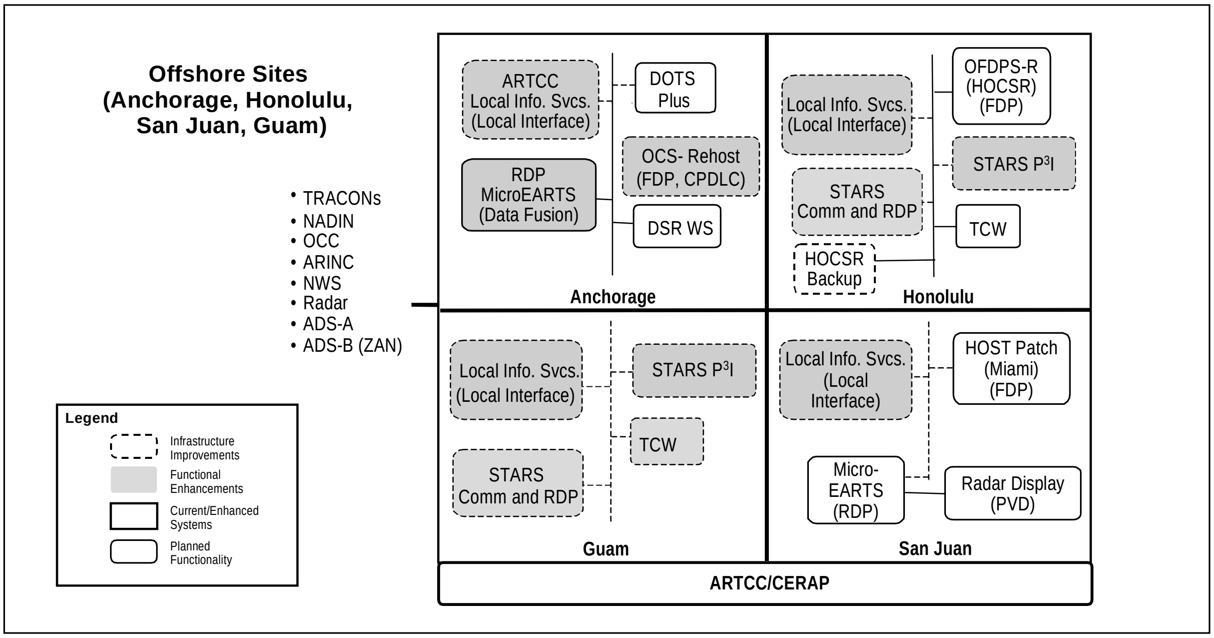

Figure 22-9. Offshore Architecture Evolution—Step 2 (2000–2004)

mation sharing will be implemented via the local information services deployed at Guam and will incorporate unique local interfaces.

22.1.2.3 Offshore Architecture Evolution—Step 3 (2005–2007)

Figure 22-10 depicts Step 3 of the offshore architecture for the four offshore sites.

Anchorage

The OCS-R will continue providing FDP functionality. The ARTCC local information services at Anchorage will be upgraded and unique oceanic interfaces will be incorporated. The local information services will provide the capability for a data repository, in accordance with standards developed for the NAS-wide information network (see Section 19, NAS Information Architecture

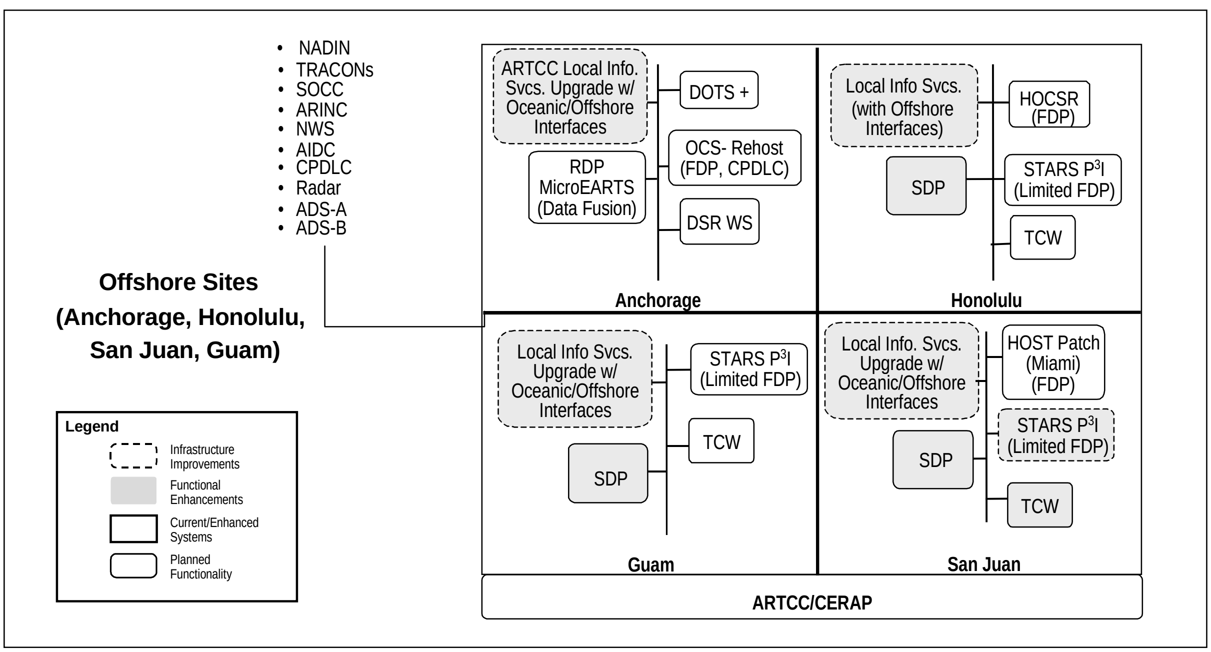

Figure 22-10. Offshore Architecture Evolution—Step 3 (2005–2007)

and Services for Collaboration and Information Sharing), that will enable the sharing of common information between FAA facilities.

Honolulu, San Juan, and Guam

San Juan's MicroEARTS system will be replaced by the STARS and the terminal controller workstation (TCW). The STARS functionality will be upgraded to coincide with the annual deployment of STARS P^{3}I enhancements (see Section 23, Terminal). The common reengineered surveillance data processor (SDP) will be deployed. Limited FDP capabilities will also be provided in STARS during this period. Upgraded local information services with unique offshore interfaces will be deployed along with the NAS-wide information network.

22.1.2.4 Offshore Architecture Evolution—Step 4 (2008 and Beyond)

Figure 22-11 depicts Step 4 of the offshore architecture for the four offshore sites.

Anchorage

This step initiates the evolution from the MicroEARTS/OCS-R-based oceanic flight data management, surveillance data processing, and initial oceanic ATC decision support systems to more advanced functionality and a common infrastructure with en route. The goal is to achieve infrastructure commonality (e.g., common hardware and system software). The applications software will be common where appropriate but will also comply with the domain unique requirements necessary for operational suitability. The Anchorage system will have the architecture and capabilities described in Step 4 of the oceanic architecture evolution (see Section 22.1.1.4).

Honolulu, San Juan, and Guam

In this step, Honolulu, San Juan, and Guam will evolve from offshore site domains to an infrastructure common with the terminal domain. This step will fully implement electronic flight data management by using flight objects and the NAS-wide information network. The common infrastructure will include flight data management (FDM), surveillance data processing, and initial TRACON/offshore automation decision support systems. The goal is to achieve infrastructure commonality (e.g., common hardware and system software). The applications software will be common where appropriate but will also comply with the domain unique requirements necessary for operational suitability (see Section 23, Terminal).

22.2 Summary of Capabilities

Oceanic operational improvements are centered around improved automation systems; procedural improvements; and advanced communications, navigation, and surveillance capabilities. In the near term, RVSM will enable increased airspace

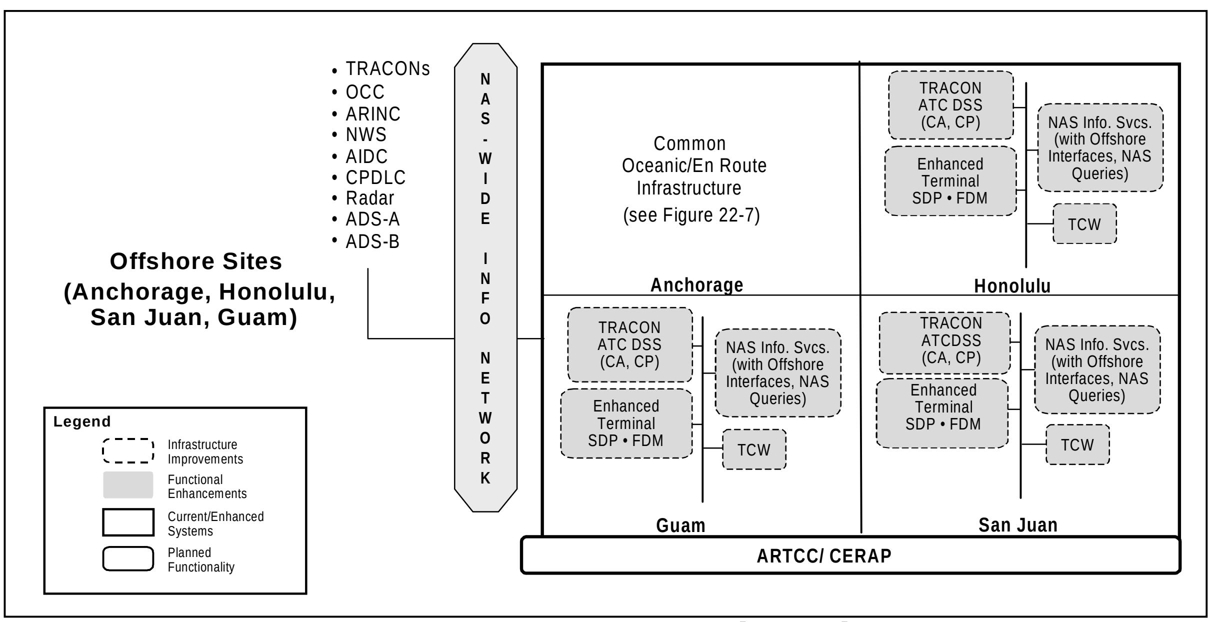

Figure 22-11. Offshore Architecture Evolution—Step 4 (2008 and Beyond)

capacity, and ODL and DOTS Plus will support dynamic rerouting and separation verification. Aircraft equipage and procedural improvements will allow the separation standards to be reduced to 50 nmi lateral in more oceanic airspace.

Automation enhancements, multi-sector ODL, ADS-A, and AIDC will enable separation standards to be reduced to 50 nmi lateral and 50 nmi longitudinal in some oceanic airspace and then eventually in all oceanic airspace. Procedural improvements, in conjunction with separation from the glass and stripless operations, may allow separation standards to be reduced beyond 50/50 nmi in some oceanic airspace. Sharing common information between oceanic and domestic sites and international FIRs will improve coordination.

Migration to an enhanced en route/oceanic automation system with advanced decision support tools and dynamic sector boundaries will support the capability for further reduction of oceanic separation standards.

The NAS-wide information network will facilitate sharing control data for collaboration between national and international air traffic service providers to determine the daily airspace structure (based on weather, demand, user preferences, and equipage), to identify and mitigate capacity problems, and to ensure seamless transition across FIR boundaries. The NAS-wide information network will improve collaborative decisionmaking between FAA and users—as will timely data link sharing of information between the oceanic service provider and the cockpit. Figure 22-12 depicts the evolution of oceanic and offshore operational capabilities.

22.3 Human Factors

Human factors methods, principles, and practices will be applied during the oceanic evolution process. Understanding the human factors issues associated with the oceanic implementation of ADS, improved navigation tools, real-time communications, and automated data exchange between pilot and oceanic service provider via data link is required. Displays and decision support tools will support the goals of increasing flexibility and efficiency through implementing dynamic rerouting (e.g., step climbs, cruise climbs, and optimum altitudes) and dynamic management of route structures (i.e., flex tracks and user-preferred profiles).

To achieve these goals requires a better understanding of which decisions to support and what specific functions DSSs will perform. Furthermore, to integrate the system across domains, boundaries, and authorities will require an in-depth understanding of the communication process between controllers in the system and how this process can be automated.

The human factors aspects of this new process will be critical, since the improved communication level and less rigid structure in the airspace will need new methods for presenting information to controllers and other users.

The primary elements of the required information to make this transition include the definition of

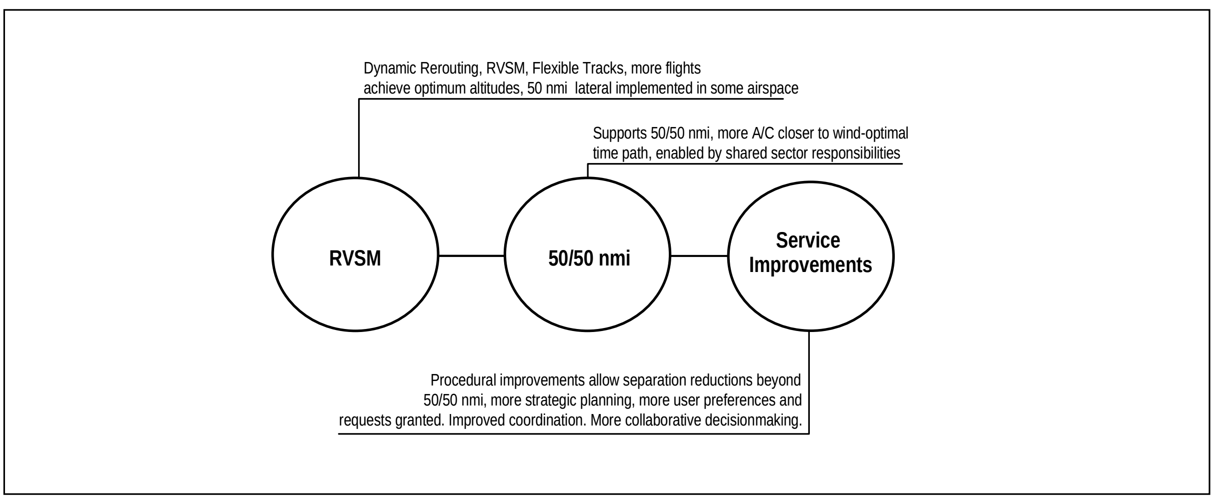

Figure 22-12. Oceanic and Offshore Operational Improvements

service provider and user functions, decision processes, information requirements, and communication processes that are necessary to accomplish the goals. This information makes it possible to integrate flight-strip information on the primary oceanic display in a manner that allows for the elimination of paper flight strips.

Human factors guidance will be provided in the area of oceanic automation and decision support systems to ensure that they will provide the anticipated user and service provider capabilities. The DSS must detect deviations and account for required oceanic procedural separation rules. Issues requiring resolution include accuracy and sensitivity of the algorithms versus the false alarm rates that are acceptable to service providers. Tools must be developed to help system designers understand what decisions should be supported, the best means to deliver the information to the service provider, and how to elicit knowledge from experts during the algorithm development process.

Using oceanic data link to issue altitude assignments, frequency changes, clearances, and weather hazard alerts will contribute to efficiency. There are human factors issues to be resolved regarding the ability of oceanic service providers to ensure that the correct messages are sent, properly received, and acknowledged. Human factors research needs to be conducted to refine and augment the human engineering guidelines for system development in data link communications to ensure that providers and users sustain or enhance their current level of situation awareness using data link communications during oceanic operations.

The process of TFM in future oceanic operations will depend heavily on collaborative decisionmaking. That is, information will be shared between service providers and users so that both parties can optimize the process of flight scheduling, routing, and maneuvering. Human factors research is required to develop alternative methods for interaction between users and service providers to enhance oceanic flexibility. The research needed encompasses development of analytical tools to evaluate the human factors aspects of how collaborative decisionmaking (CDM) will be conducted from the standpoint of communication and information transfer between users and oceanic service providers.

Inclusion of the flight deck in some shared separation responsibility requires additional human factors research to address the issues of flight deck information requirements and cross-system integration. The issue of responsibility (e.g., specific procedures and rules of the road) will be addressed and resolved before shared separation decisionmaking/responsibility occurs on the flight deck. A concerted effort will be directed at determining the capabilities and limitations of pilots and controllers so that it will be possible to change the oceanic concept of operations in a manner that results in the requisite increase in efficiency and safety.

Considerable human factors guidance is required for successful transition between stages of the oceanic system evolution process. This includes implementing data link communications and processes and the transition from procedural separation using paper strips to procedural separation using displays with integrated DSS tools.

22.4 Transition

The oceanic and offshore transition is shown in Figure 22-13.

22.4.1 Oceanic Elements

The principal elements of the transition to the oceanic architecture are as follows:

- DOTS Plus implemented at Oakland and New York
- ODL, ISD controller tools, and initial AIDC deployed at Oakland and New York
- ODAPS hardware at Oakland and New York rehosted onto the same type of platform as the Host sustainment platform (HOCSR)
- ADS-A software deployed at Oakland and New York; communications server supports ODL, ADS-A, and AIDC

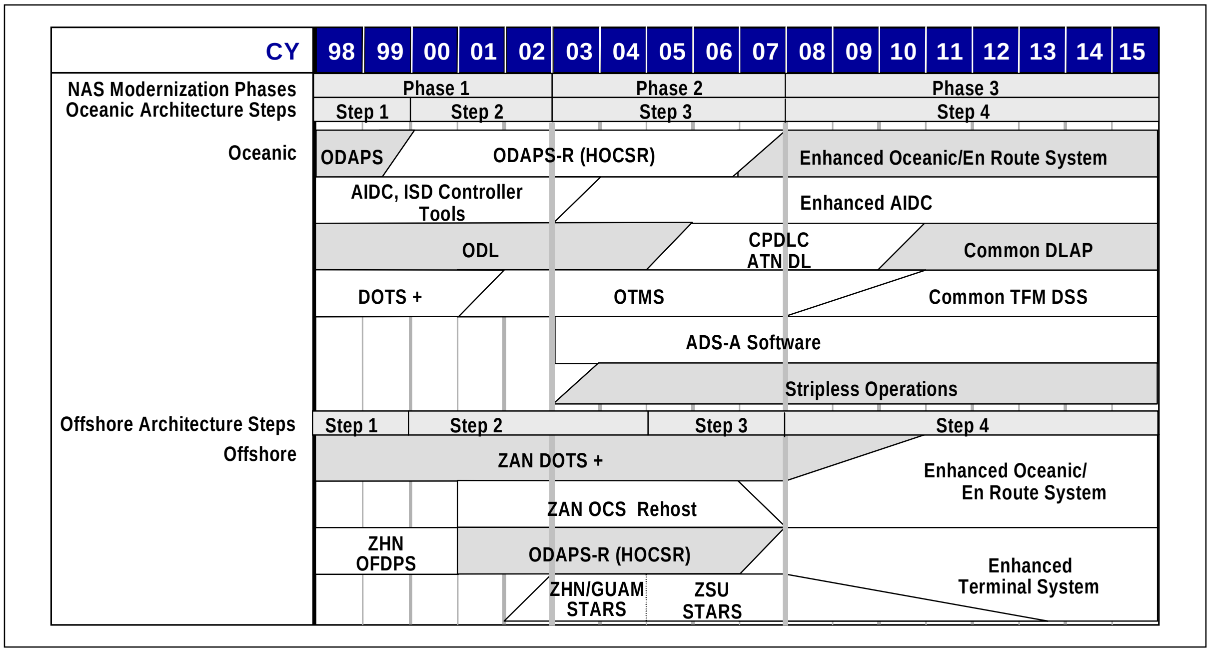

Figure 22-13. Oceanic and Offshore Transition

- OTMS functionality upgrades at Oakland and New York
- TCA, Full-Fidelity Trainer, Enhanced AIDC
- Transition to stripless operations at Oakland and New York
- FDM prototype deployed as engineering test bed
- Common DLAP supporting oceanic and domestic data link
- Introduction of NAS-wide information network
- Common oceanic/en route system deployed at Oakland, New York, and Anchorage
- Common terminal/offshore system deployed at Honolulu, San Juan, and Guam
- Functional enhancements are implemented to fully satisfy mid-term CONOPS.

22.4.2 Offshore Elements

- The principal elements of the transition to the offshore architecture are:
- DOTS Plus implemented at Anchorage
- OFDPS replaced at Honolulu (HOCSR)
- OCS replaced at Anchorage
- STARS deployed at Guam and Honolulu
- Introduction of Local Information Services at offshore sites
- STARS deployed at San Juan
- Introduction of NAS-wide information network at offshore sites
- Common terminal infrastructure for Honolulu, San Juan, and Guam
- Common oceanic/en route system for Anchorage
- Functional enhancements are implemented to fully satisfy mid-term CONOPS.

22.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for oceanic and offshore architecture from 1998 through 2015 in constant FY98 dollars are presented in Figure 22-14.

22.6 Watch Items

A current study is investigating a number of innovative alternatives to meet oceanic user needs and FAA commitments to reduce separation standards. This effort focuses on an FAA/industry partnership to deliver benefits earlier than is cur-

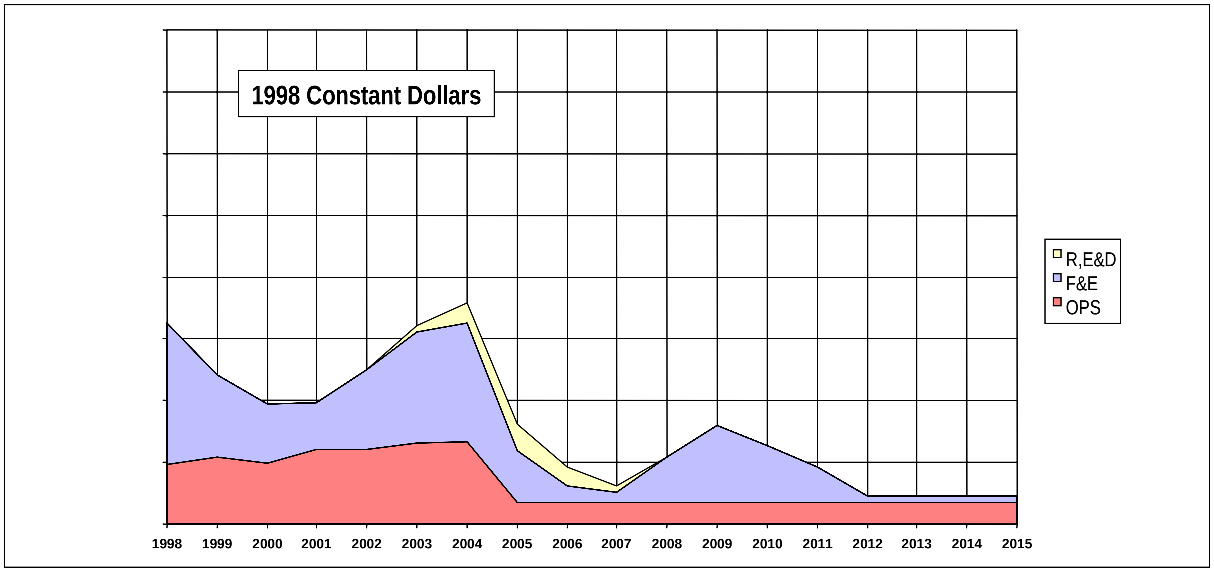

Figure 22-14. Estimated Oceanic and Offshore Costs

rently affordable with FAA funding. System capacity will not keep pace with growth in traffic volume until improvements are made to the oceanic ATC system.

The oceanic and offshore architecture evolution will require new procedures, regulations, standards, and certification of all systems whose failure could affect flight operations safety. New operating procedures will be required for reduced separation standards, flexible routing, and increased use of automated information exchange between aircraft, service providers, and international FIRs. Standards for message formats and content must be generated and agreed upon internationally.

Implementing oceanic capabilities and achieving the oceanic and offshore functionality and subsequent operational benefits described in the architecture depends on adequate funding, which has been and continues to be a problem. Thus, successful implementation of the oceanic architecture will depend on the success of related activities in other domains (described below).

- Demonstrate the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS; to merge these data with radar data and pilot position reports; and to display this information to controllers with an acceptable computer-human interface (CHI)

- Timely deployment of ODAPS, OFDPS, and OCS hardware supportability solutions that solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the evolving systems necessary to meet future requirements

- The budget for incorporating some of the future functionality is related to development of common algorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

  – Surveillance processing and ADS data fusion in the terminal, en route, oceanic, and surface domains

  – Weather services

  – Flight object processing (FDM)

  – Functionality in some ATC DSS and safety-related tools.

23 TERMINAL

The primary task of air traffic control (ATC) in the terminal domain is to ensure that aircraft are safely separated and sequenced within the airspace immediately surrounding one or more airports. Terminal automation systems provide the terminal radar approach control (TRACON) facilities with capabilities for controlling arriving, departing, and overflight aircraft and provide tower facilities with terminal radar aircraft situation displays. TRACON facility controllers, with support from a co-located traffic management unit (TMU) (at some high-activity locations), manage the flow of air traffic in the terminal airspace.

The future terminal architecture accommodates the projected air traffic growth through automation enhancements and procedural changes to improve capacity, reduce maintenance costs, and provide the foundation for future enhancements. A combination of ground and airborne automation capabilities will allow flexible departure and arrival routes and reduce and/or eliminate speed and altitude restrictions in the terminal domain. A major driver of the terminal architecture is to lower operations and maintenance costs by evolving toward maximum commonality between offshore and domestic air traffic services.

As described in Section 22, Oceanic and Offshore, the ATC automation systems at offshore sites (Guam, San Juan, and Honolulu) will evolve toward automation systems commonality with the terminal domain. The concept of commonality is that the offshore facilities will evolve to the terminal infrastructure and the applications software as appropriate, but they will also utilize domain- and site-specific capabilities necessary for operational suitability.

The FAA and the Department of Defense (DOD) will replace all of their terminal automation systems in the NAS with the Standard Terminal Automation Replacement System (STARS). STARS is an all-digital system based on an open system architecture.

The terminal architecture will evolve to provide the following enhanced capabilities:

- Improved arrival and departure sequencing based on surface traffic, airline preferences, and traffic flow information
- Integrated display of weather and aircraft positions based on primary/secondary radar, and automatic dependent surveillance (ADS) information
- Conformance monitoring, conflict detection, and conflict probe functionality
- Automated exchange of real-time flight data among aircraft, ATC facilities, airline ramp control, and airline operations centers (AOCs) to support collaboration
- Integration of surface and terminal automation.

These enhancements will allow for improvements such as:

- Reduction and/or elimination of terminal area speed and altitude restrictions
- Flexible departure and arrival route structures and possible reduced separation.

23.1 Terminal Architecture Evolution

The terminal architecture evolves from an infrastructure composed of various FAA and DOD automation systems to a standard infrastructure—STARS. The evolution of STARS includes preplanned product improvements (P^3I) to support enhanced functionality, as well as periodic upgrades to ensure future maintainability and supportability.

During a four-step evolution, the terminal architecture will integrate capabilities that will also satisfy many offshore automation requirements. The following diagrams show each evolutionary step in a logical or functional representation without any intention of implying a physical design or solution.

The STARS deployment program will install systems at 170 FAA and 36 DOD terminal facilities over approximately 6 years. The current equipment (i.e., automated terminal radar system (ARTS IIA, IIE, IIIA, IIIE)) and associated displays and peripherals and the DOD programmable indicator data processor (PIDP)) will be decommissioned. STARS P^3Is will incrementally provide new functionality and enhancements (see Figure 23-1).

PART III

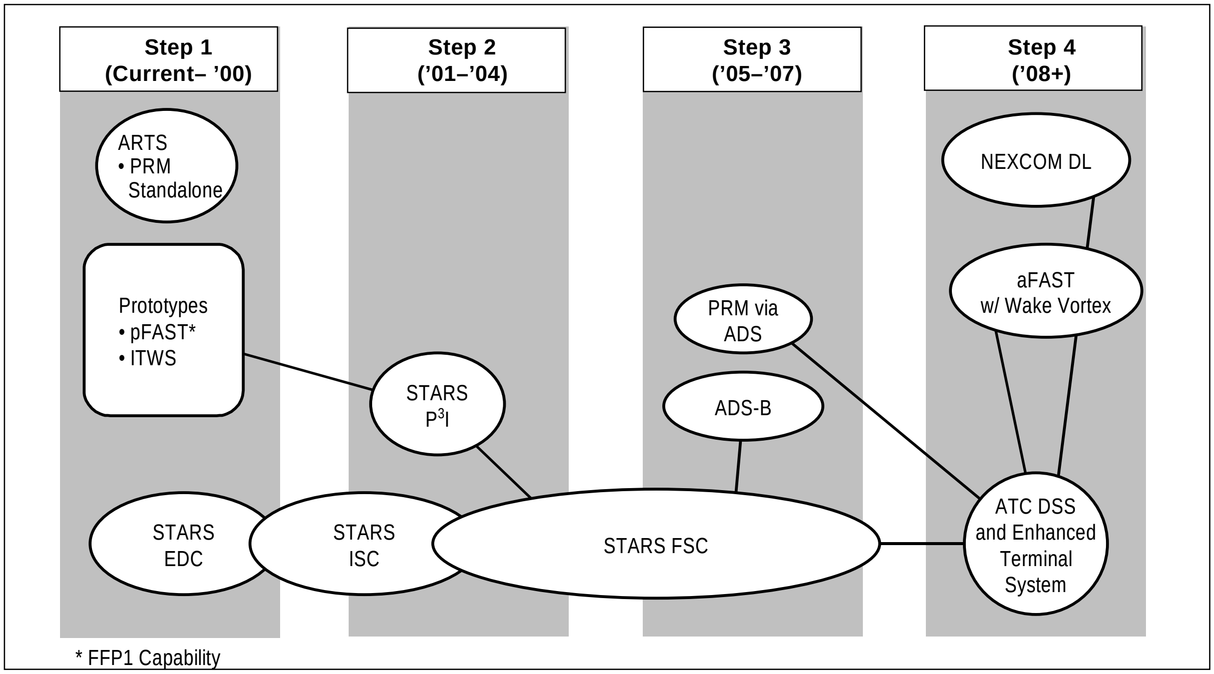

Figure 23-1. Terminal Architecture Evolution

23.1.1 Terminal Architecture Evolution—Step 1 (Current–2000)

In this step, current terminal automation systems will begin to be replaced with more modern systems that provide the foundation for future enhancements (see Figure 23-2). Step 1 consists of the current automation systems and the initial STARS implementation.

Current Automation Systems

The current terminal automation systems consist of computer processing and display systems that are used in conjunction with airport surveillance radars. The current systems used within the TRACON are FAA configurations of the ARTS and the DOD PIDP (collectively referred to as ARTS). ARTS began with the ARTS I in 1964, then evolved into several configurations. The ARTS IIA and ARTS IIE are designed to provide automation support to air traffic controllers at small to medium-sized TRACONs, and the ARTS IIIA and ARTS IIIE are designed for larger TRACONs.

ARTS satisfies the requirements for tracking and identifying aircraft. In addition, the ARTS IIIA, IIE, and IIIE systems provide additional safety functions, such as conflict alert, Mode-C intruder (MCI), and minimum safe altitude warning (MSAW). Conflict alert and MCI are automated safety functions that detect unsafe proximity between aircraft pairs and provide visual and aural alerts to controllers. MSAW detects proximity between tracked aircraft and terrain and/or obstructions and provides controllers visual and aural alerts. ARTS IIA systems are being updated to ARTS IIE in order to provide these safety functions.

ARTS acquires and maintains aircraft identification, predicts future locations and altitudes, displays the information directly to a controller, and transfers the information to the next controller responsible for the aircraft. It associates the transponder code received from the aircraft via the secondary radar surveillance system with the assigned transponder code contained in the flight plan (received from the en route host computer).

ARTS provides TRACON controllers with continuous alphanumeric information on radar and data displays. This information, displayed in a data block, includes the aircraft identity, altitude, the type of aircraft, ground speed, any special equipage of the aircraft, and, if applicable, the emergency status of the aircraft.

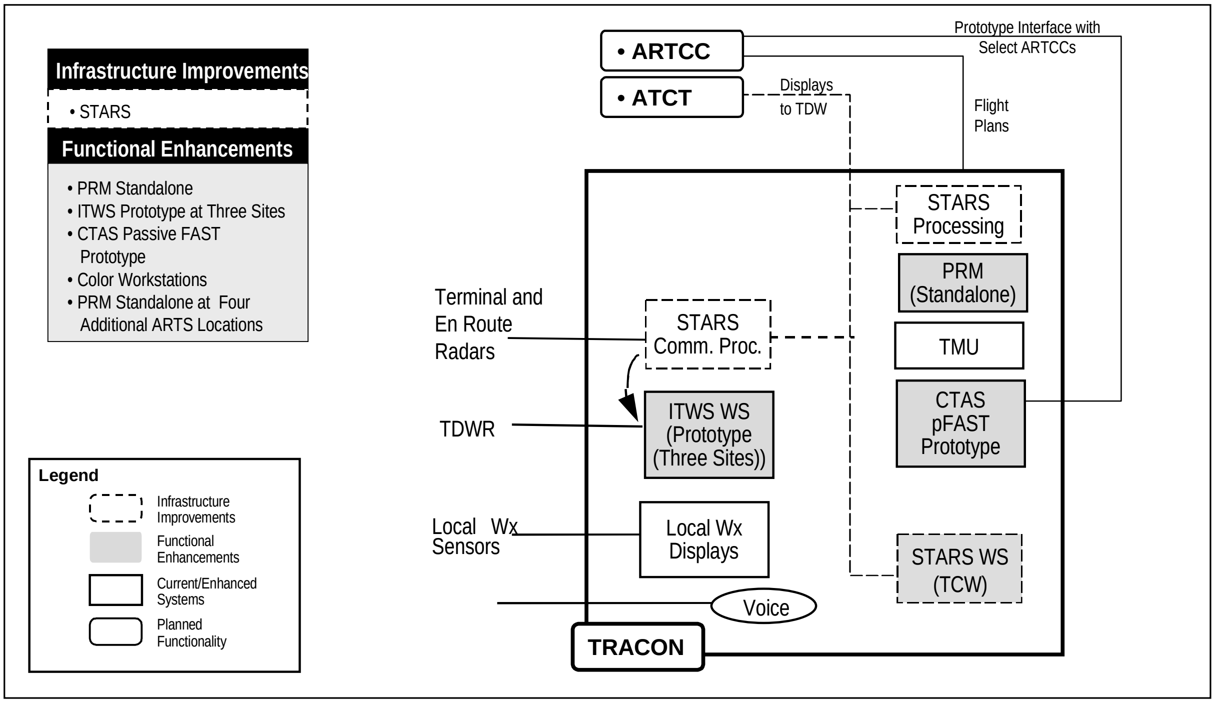

Figure 23-2. Terminal Architecture Evolution—Step 1 (Current–2000)

Specific ARTS versions also support use of the Final Monitor Aid (FMA), Converging Runway Display Aid (CRDA), and Controller Automation Spacing Aid (CASA). FMA monitors aircraft on final approaches to parallel runways and provides controllers visual and aural alerts when approaching aircraft are predicted to enter a nontransgression zone between parallel runways. CRDA and CASA are algorithms and display features that assist controllers in merging arriving traffic into a final approach sequence. CRDA and CASA functionality assists controllers in visualizing the relationships between aircraft on different flight paths in the terminal airspace and adjusting spacing between aircraft to maximize capacity. CRDA is used at airports with converging runways that have straight-in approaches. CASA is used at airports with curved approaches.

The digital bright radar indicator tower equipment (DBRITE) system is a tower display that presents radar/beacon, weather, and ARTS data to tower controllers.

Flight Data Input Output (FDIO) is a separate system that provides a capability for terminal controllers to enter and retrieve aircraft flight plans into and from the en route host computer and to print paper flight progress strips for use by terminal and tower controllers.

Other Current Capabilities

Several other capabilities currently exist or will be introduced into the terminal domain during Step 1.

Air Traffic Management. Within certain high-activity TRACONS, a TMU serves as the interface with the enhanced traffic management system (ETMS), the backbone of the current national traffic flow management (TFM) system (see Section 20, Traffic Flow Management). The TMU provides a projection of aircraft demand for primary airports via the monitor alert functions and the aircraft situation display. Monitor/alert informs the traffic management coordinator when projected traffic flows will exceed capacity and provides a means for adjusting flows in coordination with the Air Traffic Control System Command Center (ATCSCC) and the AOCs.

Center TRACON Automation System (CTAS)/ passive Final Approach Spacing Tool (pFAST). A CTAS/pFAST prototype is in operation at the Dallas-Fort Worth TRACON, interfacing with the ARTS-IIIE. Based on its mature status as a research and development prototype program, CTAS/pFAST was selected for deployment at additional sites as a part of Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) to provide early benefits to ATC and NAS users in the terminal domain. pFAST is an automation tool that assists terminal controllers in sequencing and spacing arrival traffic. pFAST integrates radar sensor, flight plan, aircraft performance, and weather data. The pFAST processor algorithms sequence and merge aircraft approaching the airport from different directions. Aircraft are merged into a steady arrival stream, which balances runway utilization, increases traffic-flow efficiency, and helps pilots conserve fuel. pFAST sends the aircraft and sequencing data for display at controller workstations. The pFAST functionality is modular and will be developed in several incremental builds that will progressively increase the tool's sophistication.

Integrated Terminal Weather System (ITWS). ITWS, currently a prototype system at three locations (Dallas-Fort Worth, Orlando, and Memphis TRACONs), functions as a weather server in the terminal domain. ITWS integrates weather from terminal Doppler weather radar (TDWR) and airport surveillance radars (ASRs) for display at terminal facilities. It also provides alerts and short-term forecasts of terminal weather conditions (see Section 26, Aviation Weather).

Parallel Runway Monitor (PRM). PRM allows independent simultaneous parallel approaches under instrument meteorological conditions (IMC) for parallel runways spaced from 3,400 to 4,300 feet. The PRM consists of an electronically scanned surveillance radar with 1-second update and a high-resolution color display. PRM requires track and flight plan data from the terminal automation system. Currently a one-way interface from ARTS to the PRM has been defined.

PRM provides controllers with visual and aural alerts when an approaching aircraft is predicted to blunder into the nontransgression zone between the runways. It was commissioned at Minneapolis-St. Paul in 1997 and St. Louis in 1998 and is scheduled for implementation at three additional terminal facilities (New York (John F. Kennedy Airport), Philadelphia, and Atlanta).

Tower Interface Systems

Two Tower prototype programs, the Airport Movement Area Safety System (AMASS) and the surface movement advisor (SMA), require an interface with the terminal automation system to receive track and flight information.

Airport Movement Area Safety System. AMASS, currently a prototype system at the Detroit and St. Louis airports, will be deployed to 34 airports. It alerts tower controllers to potential aircraft conflicts on the airport surface via audible cautions and warnings and visual information superimposed on the airport surface detection equipment (ASDE)-3 display (see Sections 16, Surveillance, and 24, Tower and Airport Surface).

Surface Movement Advisor. The SMA prototype developed at Atlanta is planned for implementation at selected facilities. The prototype shares information among air traffic, the airlines, and the operations community. However, to provide early benefits to users as part of FFP1 CCLD, SMA has been redefined to provide a form of limited collaborative decisionmaking (CDM) capability. Specifically, initial SMA for FFP1 CCLD will provide aircraft arrival, departure, and airport status information via ARTS to airline ramp control operators (see Section 24, Tower and Airport Surface).

STARS Implementation Phase

Current automation systems will be unable to meet growing traffic demands or readily incorporate new functionality. The FAA needs an open, expandable terminal automation platform that can accommodate current and future needs. STARS will replace the various ARTS systems at FAA TRACONs and PIDP at DOD facilities with modern displays and distributed processing network architectures. STARS will also replace DBRITE with the tower display workstation (TDW) to provide equivalent ATC operational functionality.

STARS provides a standard automation architecture that is scalable across all TRACON facilities. It will reduce costs for software changes, improve software portability and documentation, reduce hardware and software maintenance and training, and provide the capacity for future growth. STARS will also provide color displays for terminal and tower controllers (i.e., terminal controller workstations (TCWs) and TDWs) to increase the amount of information that can be displayed and to improve data discrimination. STARS requires digitized radar data from surveillance systems (see Section 16, Surveillance) to process tracking and will provide multiple radar sensor tracking and mosaic display.

STARS functionality will be delivered in three capability configurations. The early display configuration (EDC) will interface with the existing ARTS via the automation interface adapter (AIA). The ARTS backroom equipment provides the processing capability using STARS displays.

The STARS initial system capability (ISC) and final system capability (FSC) configurations modernize the automation of terminal facilities and provide a single automation solution, while overcoming the deficiencies of the current terminal automation systems. (FSC will not be implemented until Step 2.) STARS also provides an evolutionary path to provide new functionality as it becomes available. FSC will incorporate FMA, CRDA, CASA, and a maintenance interface to the operational control centers (OCCs). The OCC interface will be used for remote monitoring and control of STARS.

23.1.2 Terminal Architecture Evolution—Step 2 (2001–2004)

During this period, deployment of STARS to all FAA TRACONs will continue, as will national deployments of CTAS/pFAST, PRM, AMASS, and ITWS (see Figure 23-3). STARS P^{3}I planning includes a limited set of FDP capabilities to enhance STARS. STARS will replace the Microprocessor En Route Automated Tracking System (MicroEARTs) systems at two offshore facilities (Honolulu center radar approach control (CERAP) and Guam) (see Section 22, Oceanic and Offshore).

Functionality enhancements to STARS will be provided in a series of “packages.” It is anticipated that these packages will be implemented one per year for several years. The first planned package includes interfaces to pFAST, PRM, AMASS, and SMA. These systems, which had been interfaced to ARTS as prototypes, will begin national deployment. The All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX), free-form text, and terminal controller position-defined airspace will also be implemented. Definition of these STARS enhancements follow:

PART III

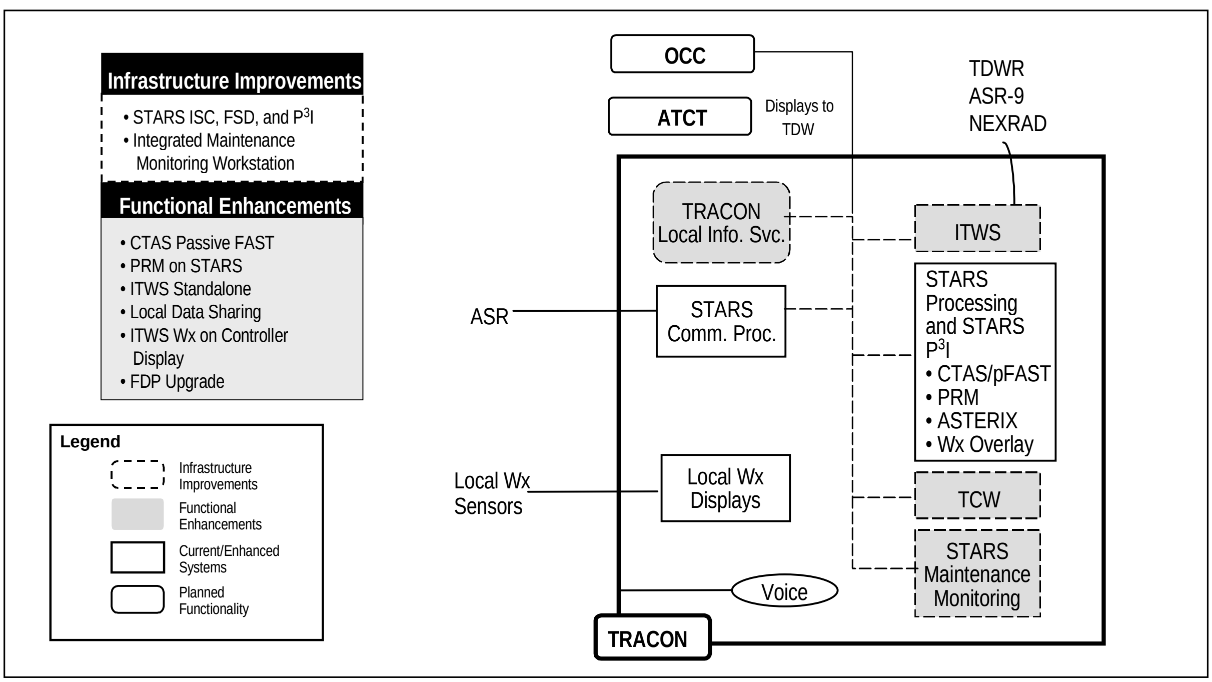

Figure 23-3. Terminal Architecture Evolution—Step 2 (2001–2004)

All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX). This is a digital surveillance message format currently being standardized under the leadership of EUROCONTROL.[1] ASTERIX will permit a sensor to transmit surveillance data with increased precision and a unique aircraft identification code in the target position report. This identification will be used for surveillance processing/tracking and separation assurance function enhancements. ASTERIX will enable other surveillance processing enhancements, such as selective interrogation (SI) and processing automatic dependent surveillance-broadcast (ADS-B) data (see Section 16, Surveillance). ASTERIX will be implemented with the interface to the ASR-11, ATCBI-6, and Mode-S radar systems being procured.

Free-Form Text. This function allows the controller to input and place alphanumeric text anywhere on the STARS TCW/TDW displays. The function replaces handwritten notes that are used during the controller relief briefing. Free-form text is a safety enhancement to ensure information is available and in view of the controller.

Terminal Controller Position-Defined Airspace. This allows the controller to define an airspace (i.e., temporarily restricted airspace) and display it on the TCW/TDW. This capability ensures safe operations in the vicinity of special aviation activities (e.g., parachute jumping) and will facilitate other safety critical operations, such as release of instrument flight rules (IFR) traffic at uncontrolled airports, release of volumes of airspace to other sectors, and providing reminder messages for procedures temporarily changed due to equipment outages or weather conditions.

Candidates for other P^{3}I packages to be implemented during this period include:

Automated Barometric Pressure Entry (ABPE). Currently, controllers manually enter the barometric pressure reference used by the terminal automation system. The current setting is obtained from direct-reading instruments or digital altimeter setting indicators (DASIs) or the nearest weather reporting station. The altimeter setting affects an aircraft's altitude displayed to the controller. ABPE adds a STARS interface to the Automated Surface Observing System (ASOS) (or the DASI) for automated input of local barometric pressures, thereby reducing controller workload and the possibility of data entry error.

STARS/STARS Interfacility Interface. Currently, the interface between terminal automation systems is via the en route Host computer system. STARS-to-STARS interfacility communications will allow a STARS facility to exchange data directly with up to seven other STARS facilities. This change will increase operational and technical efficiency and reduce the Host workload.

Flight Data Input/Output Integration Into STARS. The current FDIO in the TRACON facilities will be replaced. Integrating FDIO into STARS will include FDIO keyboard and display functionality at the TCW and a flight strip printer.

Surveillance Processing Enhancements. STARS inherent capabilities allow use of enhanced surveillance algorithms, information, and processing functions. These improved surveillance capabilities depend on the ASTERIX message format described above. The implementation of ASTERIX enables tracking, conflict alert, and Mode-C intruder alert algorithms to be improved due to increased precision of position reporting, the surveillance file numbers correlating targets to tracks, and the time stamps for target reports.

ITWS Weather on Controller Displays. Initially, ITWS will be a stand-alone system with the weather data available to terminal controllers on separate displays. Later, ITWS weather information will be displayed on STARS. This capability will provide convective and hazardous weather detection and prediction information (from ITWS outboard processing) directly at controller positions, thereby increasing efficiency and safety. At sites that are not receiving ITWS, the ASR-9 weather system processor (WSP) will be interfaced to STARS to display windshear information on the TCW.

Traffic Management Interface Enhancements. The ETMS upgrade is a two-way interface that will permit display of ETMS data on the TCW.

1. The European Organization for the Safety of Air Navigation.

Another candidate functionality for implementation (depending upon funding) during this time period is:

Flight Data Processor (FDP) Upgrade. Currently, flight data are processed by the en route Host computer at the ARTCCs. The offshore sites are not within ARTCC airspace, and thus are not supported by this FDP capability. A limited set of FDP capabilities is required for STARS to fully replace the current MicroEARTs and unique local FDP systems at Honolulu, San Juan, and Guam (see Section 22, Oceanic and Offshore). Also, FDP capabilities in STARS will reduce dependence on the en route automation system.

23.1.3 Terminal Architecture Evolution—Step 3 (2005–2007)

STARS will be delivered to a third offshore facility (San Juan) during this step.

Electronic flight data management (FDM) will be introduced through a prototype flight object processor. TRACON data will be routinely available throughout the NAS via local information sharing and the NAS-wide information network. (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing). Real-time surveillance data will be distributed from the sensors to TRACONs and from the TRACONs to other ATC facilities.

Introducing aircraft and surface vehicle ADS-B information processing and surveillance data fusion will allow enhancements to the terminal tracking and safety functions. Surveillance data processing of aircraft and surface vehicles will facilitate integration of terminal and tower data from a single automation source such as STARS (see Figure 23-4).

Surveillance Data Processor (SDP)

As secondary radar systems with selective interrogation (SI) capability are implemented, ground automation system changes will be incorporated to effectively interface with these systems.

TRACON automation will permit acceptance and processing of ADS-B position reports and the integration and fusion of ADS-B data with radar data. TRACON automation processing will be expanded to integrate terminal radar and surface surveillance data, including ground vehicles operating on the airport surface movement area. The end result is the integration of airborne and surface surveillance information on the tower displays.

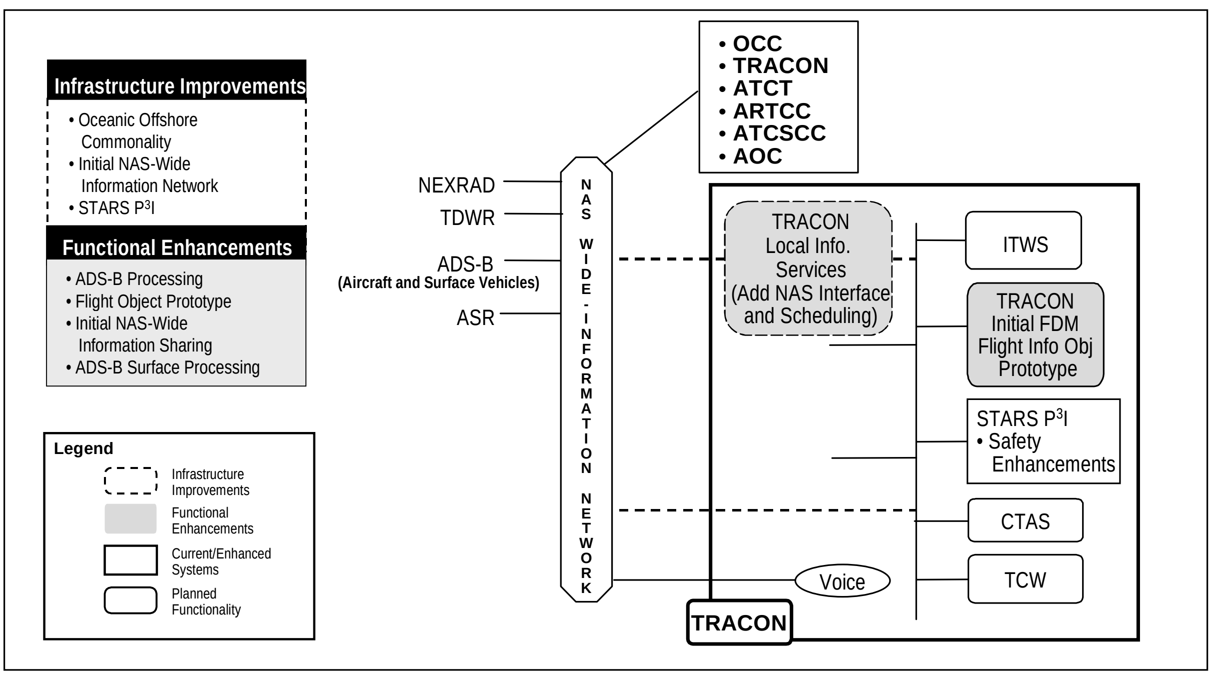

Figure 23-4. Terminal Architecture Evolution—Step 3 (2005–2007)

The integration of ADS-B data with data from surveillance sensors will require development of a multisensor fusion tracker. This ability to combine target reports from multiple sources to form a single track takes advantage of overlapping sensors and ADS-B data. This capability will improve the accuracy and availability of aircraft position data, potentially increasing the efficiency and safety of terminal operations and reducing reliance on any one sensor. Development of algorithms for terminal and en route data fusion will be done jointly, and fused surveillance data will be available for distribution to other TRACONs and ARTCCs via the NAS-wide information network.

PRM currently depends on a special electronically scanned radar to provide the rapid updates necessary to perform its monitoring function. Because of the update rates available with ADS-B, TRACON automation will be able to provide PRM functionality at many more facilities at a significantly lower implementation cost.

Safety Enhancements

Conflict alert, MCI, and MSAW are existing safety functions. The enhanced surveillance processing and tracking previously discussed will improve the probability of detection and reduce the false alarm rate associated with these functions. Merging approach and departure traffic will improve the effectiveness of conflict alert and runway incursion logic, and the display of both types of traffic on the same controller screen will improve situational awareness and safety. Incorporating intent data acquired through ADS-B will also improve conflict alert performance.

Flight Object Processor Prototype and Flight Data Management (FDM)

Currently, the ARTCC automation performs flight data processing for all aircraft within its assigned airspace, including aircraft under TRACON control. The limited set of prototype STARS FDP capabilities developed in Step 2 for the offshore facilities will be enhanced to provide FDM capabilities. This will be a coordinated effort with the en route FDM development and may become the model for the ultimate NAS-wide FDM. This FDM is an evolution from today's flight data processing capability that permits use of flight object data (defined in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing). This capability at TRACONs will eventually reduce terminal system dependence on ARTCC automation.

As local systems are replaced or new systems developed, commercial data base management systems will be used. This will enable data sharing (e.g., flight plan information, radar and weather data, maintenance information) between the various local terminal automation systems and applications (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

23.1.4 Terminal Architecture Evolution—Step 4 (2008–2015)

The logical terminal architecture is illustrated in Figure 23-5. The evolution of the terminal automation system toward a common hardware and software infrastructure for the offshore facilities will be accomplished in Step 4. Oceanic offshore automation system functionality will be fully integrated into the enhanced terminal offshore system. An FDM will be implemented to replace existing offshore and terminal FDP capabilities. The FDM expands on the FDP functionality and will use flight objects to disseminate flight status and traffic management information. The enhanced terminal and offshore system will provide an improved surveillance data processor for aircraft and surface vehicles. This automation system will allow more integrated surface and airspace operations, enabling the airport IFR capacity to more closely approach visual flight rule (VFR) capacity.

A common, modern platform infrastructure will provide for development of many advanced ATC decision support systems (DSSs). The controller, traffic flow managers, airline operation centers, pilots, and other NAS users will have access to the same DSS and information, which will enable a collaborative decisionmaking capability. The TRACON ATC DSS will integrate conformance monitoring, conflict resolution, and conflict probe capabilities as a coordinated set of controller tools. The reliance on paper flight strips will decline. pFAST capabilities will be upgraded to active FAST (aFAST) with greater precision in aircraft sequencing through recommended speed and

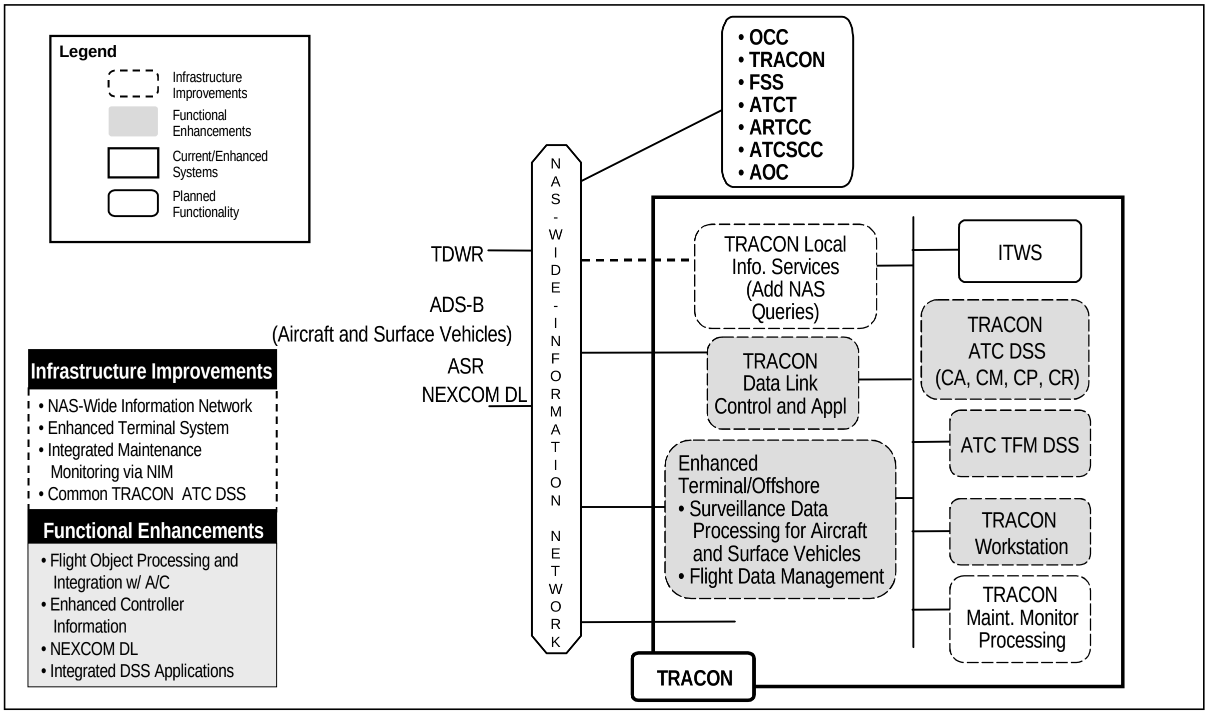

Figure 23-5. Terminal Architecture Evolution—Step 4 (2008–2015)

heading adjustments and aircraft wake vortex information in the spacing calculations to increase safety.

Data link capabilities will migrate from the service provider capability in the tower domain to the next-generation communication systems (e.g., NEXCOM). Full ATN-compliant controller-pilot data link communications (CPDLC) Build 3 service will support air-ground data exchange. The enhanced terminal automation system will use data link for communications and ADS-B to provide more accurate aircraft position reporting. This will allow more efficient use of terminal airspace and application of revised separation assurance standards. Eventually, with improved ground-based separation assurance and decision-making tools, used in conjunction with advanced cockpit display of surrounding traffic, pilots may be able to fly self-separation maneuvers during IFR conditions in the terminal area. This provides the capability to achieve VFR runway acceptance rates during IFR conditions.

An upgraded TDW that supports the integration of tower automation functions with terminal automation will be provided (see Section 24, Tower and Airport Surface).

The NAS-wide information network will conform to NAS-wide data standards, incorporate multilevel access control and data partitioning, provide data security, allow real-time data accessibility via queries, and assume all data routing and distribution functions, including data link. (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

23.2 Summary of Capabilities

Evolutionary refinements to terminal automation systems will result in DSSs that support flexible departure and arrival routes by using satellite-based navigation and improved communications and surveillance capabilities. Surveillance data processing will be performed in the terminal domain using a common processing system for both dependent surveillance data and radar/beacon data for ground and airborne traffic (see Figure 23-6).

The NAS-wide information network will provide exchange of real-time flight data among aircraft, ATC facilities, and AOCs, enabling a collaborative decisionmaking capability. Terminal automation improvements will also provide new interfaces for communications with external systems (e.g., CTAS/pFAST, PRM, SMA, AMASS, and

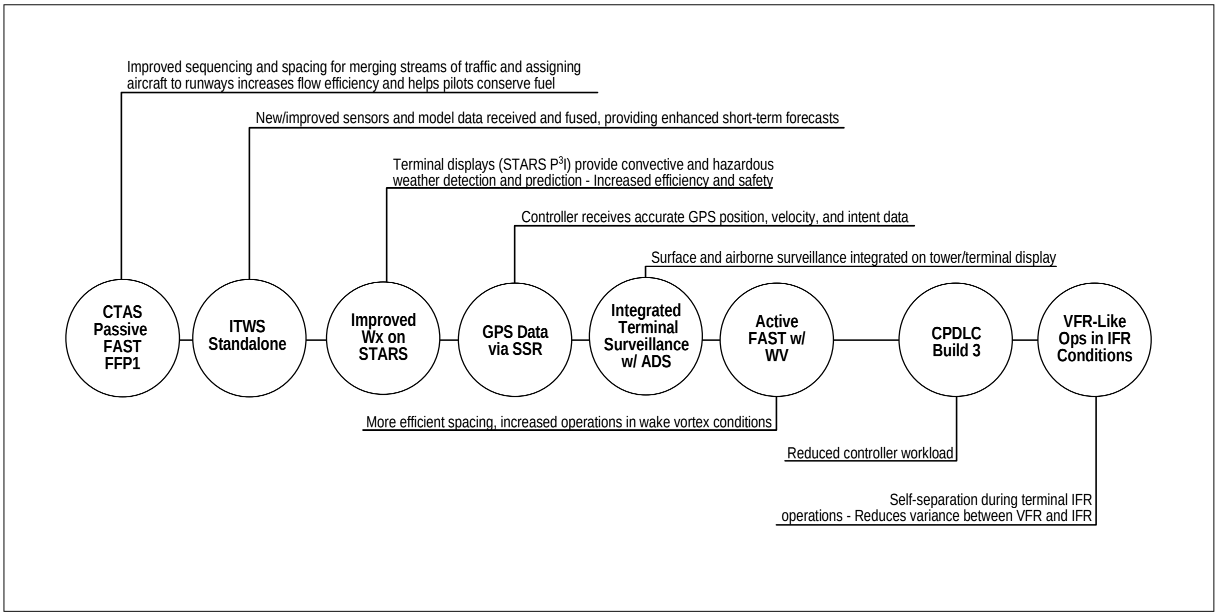

Figure 23-6. Terminal Architecture Evolution

ITWS). These new interfaces will add the capability to provide automation-generated data, such as tracks and flight plans to external systems, as well as a capability to receive and process data from external systems. In addition, the improvements will support surveillance system enhancements, improved weather display, data link, and conflict alert and Mode-C intruder alert enhancements.

The terminal automation suite will process surveillance data for surface vehicular traffic as well as aircraft for use in both the tower and terminal areas. The terminal automation suite will migrate to an enhanced terminal/offshore automation system that will evolve to a full set of TRACON ATC DSSs and TFM DSSs. The NAS-wide information network will improve collaborative decisionmaking between FAA and users.

The terminal automation system will use a digital data communications channel between terminal controllers and the aircraft in terminal airspace. This channel will supplement the controller's existing voice channel, and will allow the controller to move many of the regular and routine functions from the voice (very high frequency (VHF)) radio communications to a second, parallel communications channel. Studies have shown that this terminal data link application, computer-human interface (CHI), and second data communications channel will help terminal controllers to communicate with pilots more effectively, manage terminal airspace more efficiently, and to potentially enable significant user cost savings.

23.3 Human Factors

New hardware and software tools will improve the way controllers conduct terminal operations and provide traffic management services. Human factors efforts will focus on enhancing controller performance through:

- Upgrading the human interface with communications, new surveillance sources, and DSSs
- Using results from simulations and cognitive modeling for decision support tools to facilitate aircraft, ATC, and airline operations real-time flight data sharing
- Enhancing procedures for using surface, airline operations, and traffic-flow information for collaborative decisions involving arrival and departure sequencing
- Improving displays of new information involving airport surface movement, aircraft tracks, flight plans, and weather
- Changing training concepts to support such tools and new technologies as data link.

23.4 Transition

The terminal domain transition schedule is shown in Figure 23-7. These capabilities will be deployed during the transition:

- STARS deployment
- STARS P3I
  - – CTAS/pFAST, PRM, AMASS, SMA interfaces, Free-Form text, and ASTERIX
  - – PRM internal to STARS
  - – CTAS/a FAST
- Surface ADS-B, terminal-offshore integration
- Data link via NEXCOM
- SDP, SDP-to-off-shore
- Initiate STARS Hardware Upgrade 1 (Repeat at 6-year intervals)
- Enhanced terminal functionality
- Terminal-tower integration.

23.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for the terminal architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 23-8.

23.6 Watch Items

Achieving terminal functionality and operational benefits within the schedules and budgets described in the architecture depends on the funding and success of the following funding activities:

- Timely deployment of STARS to solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the reengineered terminal system
- Demonstrate, as a part of Safe Flight 21, the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS, to merge these data with radar data, and to display this information to controllers with an acceptable CHI. Results of these demonstrations would include processing algorithms and CHI standards that could then be incorporated into the terminal core functionality between 2005 and 2008.
- Success of the FFP1 CCLD prototypes for the terminal domain (CTAS/pFAST).

The budget for incorporating some of the future functionality is related to developing common al-

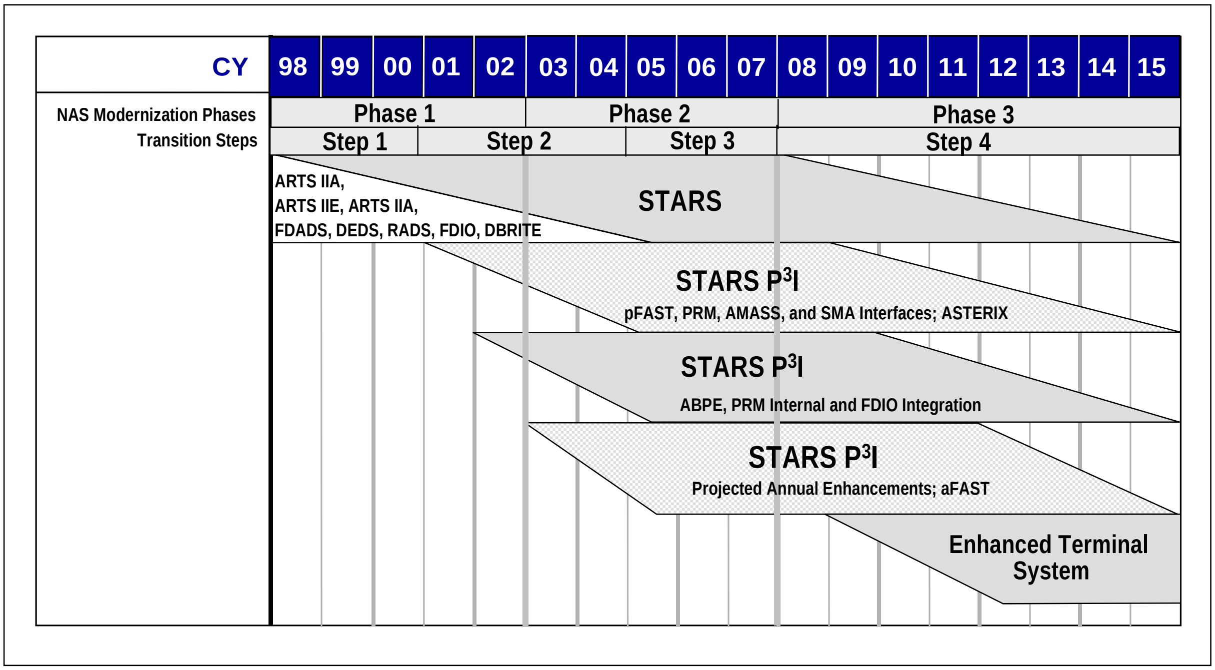

Figure 23-7. Terminal Automation Transition

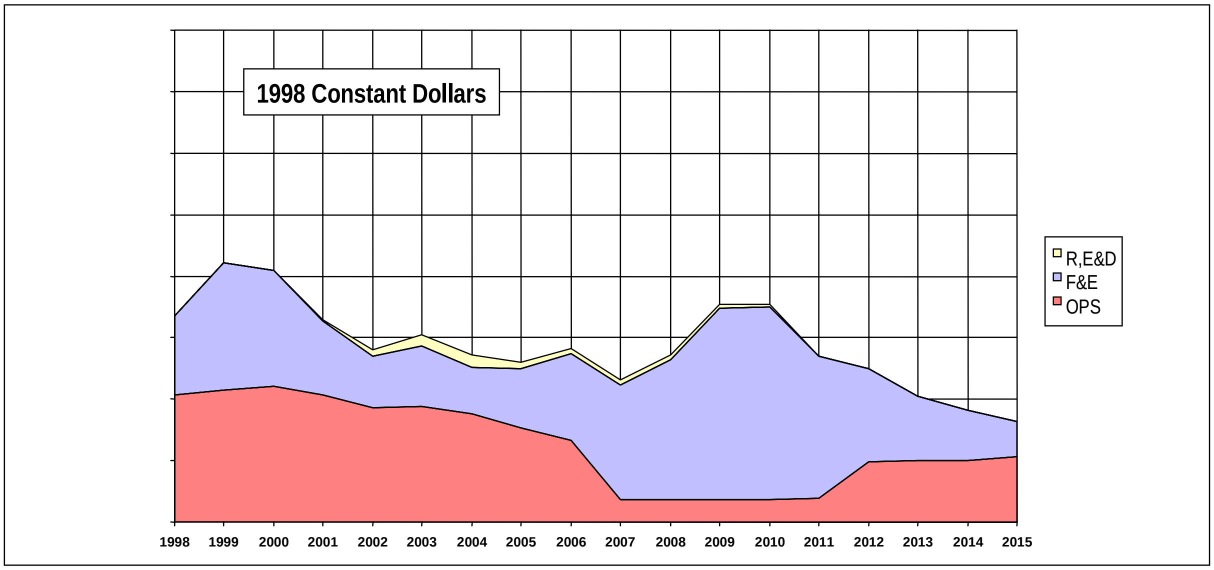

Figure 23-8. Estimated Terminal Automation Costs

gorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

- Common surveillance processing and ADS/radar data fusion in the terminal, en route, and surface domains
- Common weather services
- Common flight object processing
- Common functionality in some ATC DSSs and safety-related tools.

It is understood that this development process will increase dependencies between domains, but it is also understood that current budgets do not allow separate development in each domain. Therefore, it is essential that many of these efforts begin in the near-term to reduce long-term production risks.

24 TOWER AND AIRPORT SURFACE

Operated by the FAA, the Department of Defense (DOD), contractors to the FAA, and nonfederal organizations, airport traffic control tower (ATCT) facilities are primarily responsible for ensuring sufficient runway separation between landing and departing aircraft. ATCTs also relay instrument flight rules (IFR) clearances, provide taxi instructions, and assist airborne aircraft within the immediate vicinity of the airport.

The concept of operations (CONOPS) calls for integrating arrival and departure services with airport surface operations. Future tower and airport surface capabilities include:

- Improved information exchange and coordination activities, including expansion of data link capabilities to more users at more airports
- Automation to enhance the dynamic planning of surface movement, balancing runway demand, and improving the sequencing of aircraft to the departure threshold
- Automation to improve the identification and predicted movement of all vehicles on the airport movement area, including conflict advisories
- Safety and efficiency enhancements by planning an aircraft's movement such that a flight can go directly from deicing to takeoff without risk of requiring another deicing cycle due to taxi delays
- Integration of surface automation with departure and arrival automation so that the arrival runway and taxi route are optimally assigned with respect to the gate assignment (Current and projected areas of congestion on the surface, runway loading, and environmental constraints will also be taken into consideration.)
- Increased collaboration and information sharing among users, service providers, and airport management to create a more complete picture of airport demand.

The goal in the tower/airport surface domain is to improve the exchange of information not only between service providers and actively controlled aircraft but also among all users located at the airport. This exchange will enhance operational efficiency and safety of aircraft movement on the airport surface.

This section describes the capabilities and associated systems that are envisioned as part of the architecture for the tower/airport surface domain. It focuses on the evolution of automation in ATCTs. The evolution and expansion of data link services in the airport environment was described in Section 17, Communications. The airport architecture is discussed in Section 28, Airports.

Figure 24-1 depicts the future ATCT architecture for high-activity towers, which includes the following components:

- Controller workstation networks
- Dedicated ATCT local area networks (LANs) for transferring data and information between facilities
- Enhanced next-generation information display systems (E-IDSs)[1] for consolidating status and control devices in the tower cab
- Upgraded tower display workstations (TDWs) for integrating tactical and strategic decision support applications and facilitating the addition of newer capabilities into tower cabs
- LANs in terminal radar approach control (TRACON) and air route traffic control center (ARTCC) facilities will communicate via aeronautical telecommunications network (ATN)-compatible routers over a wide area network (WAN) with an ATCT LAN.

Low- and moderate-activity towers will have less functionality and a limited number of display types.

ATCT Architecture

Controller Workstations. The long-term goal of the tower architecture is to create a modular workstation with three displays to present alphanumeric data, radar and weather information, and

1. E-IDS will be developed from the current Systems Atlanta Information Display System (SAIDS) and ASOS controller equipment (ACE) functionalities.

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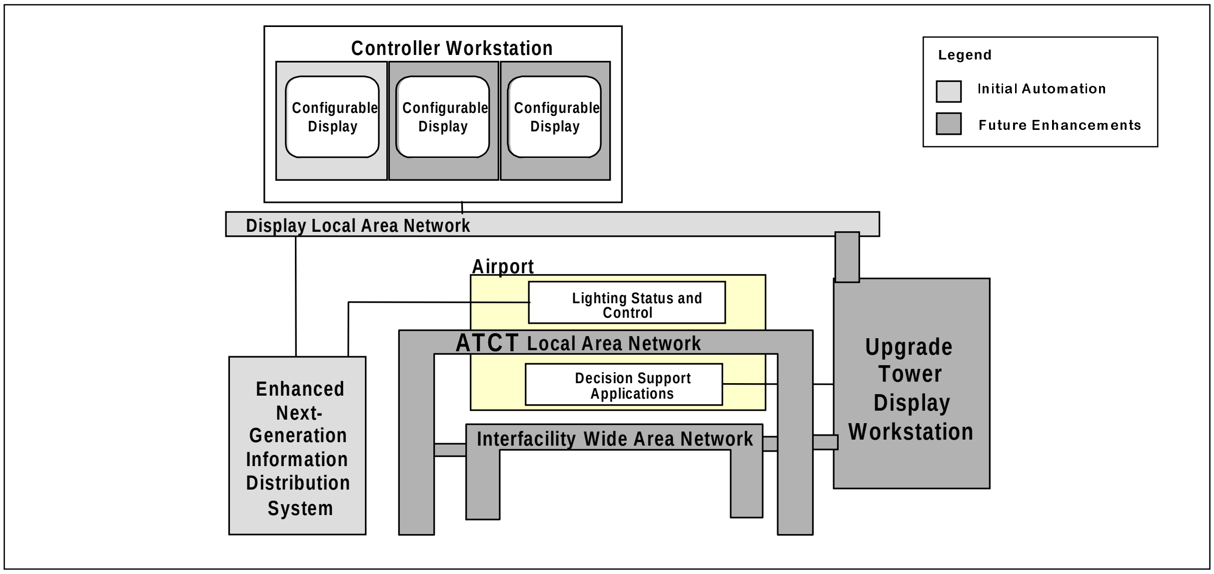

Figure 24-1. Future Airport Traffic Control Tower Functional Architecture

communications access and control information. This basic workstation can be configured to the specific needs of each type of controller position. Many positions in the tower cab do not require three displays. Wherever possible, controller workstations will be configured to reduce the number of displays. The clearance delivery position, for example, might use a single display for predeparture clearance (PDC) delivery information and for communications access and control. The local controller will likely have one display for airborne traffic, another for surface traffic, and a third display presenting consolidated status and control information. Some displays may incorporate touch-screen and/or voice recognition capabilities to reduce the amount of heads-down time spent on keyboard and trackball data entry.

Automation Enhancements. Data and information will be processed to provide new services and improve existing services displayed on the tower color display, which is suitable for high ambient light conditions. New applications will include integrating and rehosting existing functions onto controller displays.

NAS users outside the tower (such as airport managers, airline dispatchers, and ramp controllers) who need access to NAS information will connect with the tower LAN and, where appropriate, over the interfacility WAN. Access to the WAN will be restricted by suitable data security and integrity precautions.

24.1 Airport Traffic Control Tower Architecture Evolution

The ATCT architecture includes the overlapping steps shown in Figure 24-2. Step 1 maintains all currently installed tower systems, including the major ones purchased by regional or airport authorities. The three subsequent steps will replace various devices in the tower cab with new automation, integrating functions in the tower cab and interfacing with the NAS-wide information network, described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

The first improvement deploys the Airport Movement Area Safety System (AMASS) and the initial surface movement advisor (SMA) to high-activity airports. AMASS detects and alerts tower controllers of actual and potential runway incursions. Initial SMA, as defined for the Free Flight Phase 1 Core Capability Limited Deployment (FFP1 CCLD) (see Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone), provides a one-way feed of aircraft arrival, departure, and status information to ramp control operators.

The existing digital bright radar indicator tower equipment (DBRITE) displays will be replaced by the TDW displays procured under the Standard Terminal Automation Replacement System (STARS) program (see Section 23, Terminal). About the same time, data link delivery of taxi clearances (DDTC) (the prototype currently being

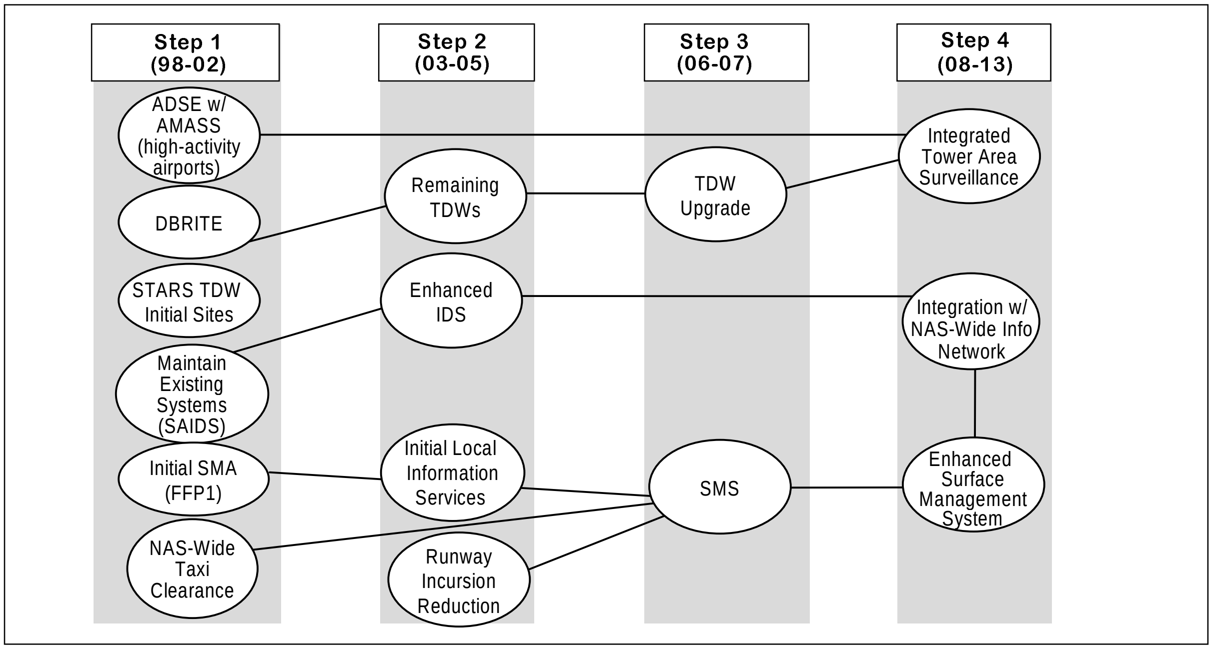

Figure 24-2. Airport Traffic Control Tower Architecture Evolution

evaluated in Detroit) is anticipated to be deployed nationally to provide new capabilities to the ATCT domain. E-IDS will be deployed to consolidate status and control devices in the tower cab.

A fully operational surface management system (SMS), which evolved from the Atlanta airport prototype of the SMA, will be installed at high-activity airports. An upgraded TDW will be implemented in high-activity towers, which will enable controllers in those towers to monitor both surface and airborne traffic via an integrated surveillance display, configurable to the particular needs of the control position in the tower. (Some positions may still use two situation displays—one configured for surface and another configured for airborne.) Subsequent sections describe these transition steps in more detail.

The following paragraphs present the tower and airport surface architecture evolution in more detail. The architecture diagrams show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

24.1.1 Airport Traffic Control Tower Architecture Evolution—Step 1 (Current–2002)

Figure 24-3 illustrates the first step in the evolution from the current ATCT architecture to the future ATCT architecture. This step establishes a nationally managed maintenance program to improve configuration management and the coordination and maintenance of the many nonstandard tower systems, including those purchased by regional or airport authorities.

The immediate problem addressed in this step is establishing a NAS-level maintenance program for the Systems Atlanta Information Display System (SAIDS). SAIDS is a proprietary display system that provides tower controllers the capability to receive and disseminate locally determined airport information, including weather and airport advisories. It is installed in more than 200 ATCTs and 25 associated TRACON facilities. SAIDS is also installed in more than 300 other facilities—including some ARTCCs, regional FAA offices, flight service stations, military air bases, and non-government facilities.

These systems were not installed under a national program, and all maintenance is performed through commercial contracts. A mission analysis is currently underway to investigate the upgrade of SAIDS to NAS standards, establish configuration control over the system, recognize it as an official FAA program, and integrate it into the FAA's overall NAS maintenance program.

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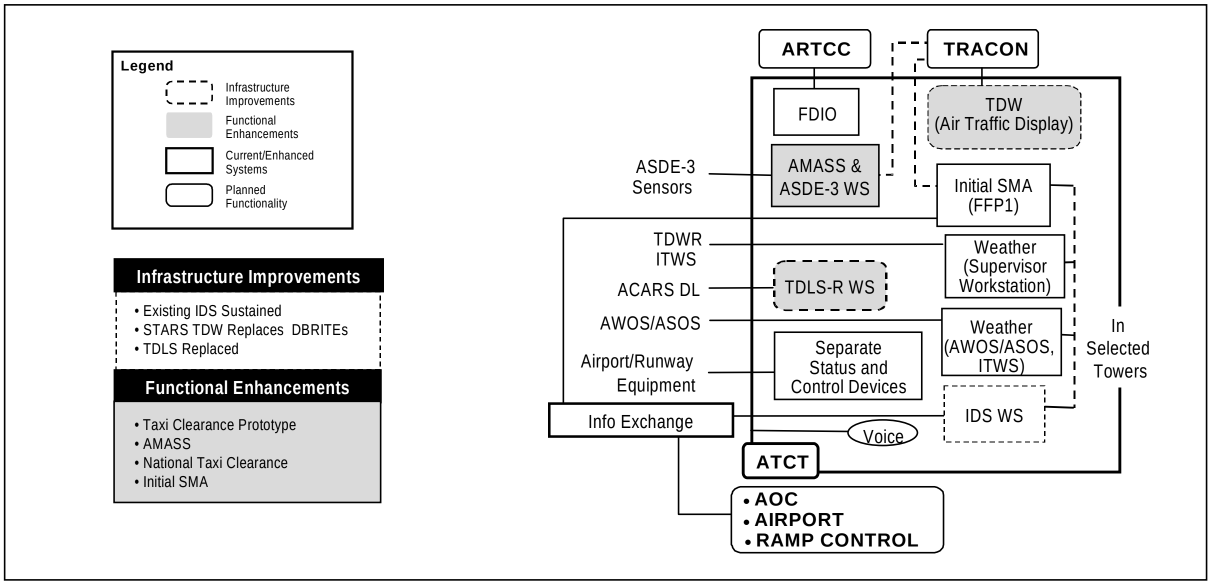

Figure 24-3. Airport Traffic Control Tower Architecture Evolution—Step 1 (Current–2002)

AMASS provides alert information to controllers of potential conflicts between arriving aircraft and surface traffic or between aircraft and vehicles on the surface via audible cautions and warning and visual information superimposed on the airport surface detection equipment (ASDE-3) display in ATCTs.

AMASS is scheduled for deployment to 34 high-activity airports. Prototypes are currently installed at Detroit and St. Louis. AMASS requires a one-way interface to receive data from the terminal automation system. AMASS processes surveillance data from the terminal automation system (automated radar terminal system (ARTS) and/or STARS), ASDE-3, and the airport surveillance radar-model 9 (ASR-9) to define the position, direction, and velocity of all airport targets.

A redefined initial SMA will be implemented as part of FFP1 CCLD to achieve early benefits to ATC and NAS users by providing a form of limited collaborative decisionmaking capability. Specifically, initial SMA for FFP1 CCLD will provide aircraft arrival information through the terminal automation system (ARTS and/or STARS) to airline ramp control operators.

During this step, TDW displays procured under the STARS program will begin to replace DBRITE displays.

Data from all local weather sensors/processors (terminal Doppler weather radar (TDWR), low-level windshear alert system (LLWAS), runway visual range (RVR), automated surface observing system (ASOS), and the airport surveillance radar–model 9 (ASR-9) weather channel) will begin to be available from the TRACON-installed integrated terminal weather system (ITWS) at 45 high-activity airports. From these sources, ITWS will provide both tower and terminal service providers with a set of airport weather products, including warnings of the most severe forms of windshear, turbulence, thunderstorm, heavy snow, and aircraft icing potential hazards (see the discussion on weather systems in Section 26, Aviation Weather).

Transmission of taxi clearances via data link (the DDTC prototype is currently being evaluated in Detroit) is expected to be deployed nationally. During this transition period, PDCs and digital automatic terminal information services (D-ATIS) will continue to be provided over the aircraft communications addressing and reporting system (ACARS) via ARINC.

PDC assists the tower clearance delivery specialist in composing and delivering departure clearances. The automatic terminal information service (ATIS) equipment enables controllers to formulate ATIS text messages for delivery. The ATIS text messages are then delivered to flight crews

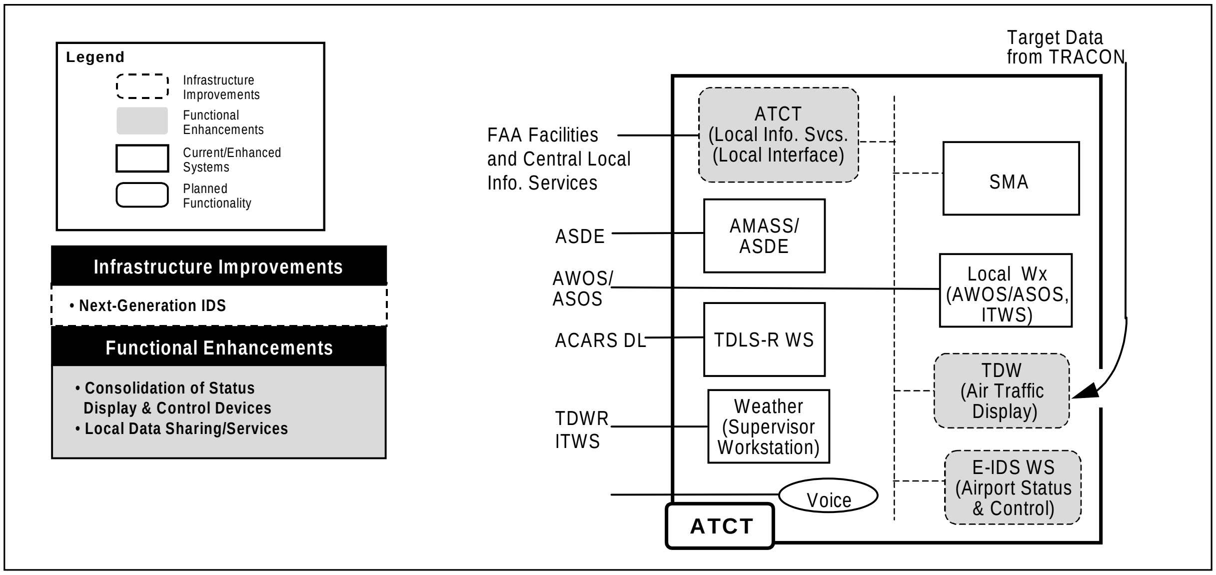

Figure 24-4. Airport Traffic Control Tower Architecture Evolution—Step 2 (2003–2005)

via ACARS data link. An ATIS automatic voice generation function produces spoken broadcasts using a synthesized voice to read the ATIS message.

24.1.2 Airport Traffic Control Tower Architecture Evolution—Step 2 (2003–2005)

Figure 24-4 depicts the transition during Step 2. The TDW will have replaced most remaining DBRITEs.

E-IDS will be implemented to reduce the number of displays and data entry devices. E-IDS uses an open system architecture to integrate the functionality of SAIDS and ASOS controller equipment (ACE), centralize the status indicators and control of airport lighting systems, eliminate multiple manual panels scattered throughout the tower cab. E-IDS will increase the timeliness and quality of weather, traffic, and system status data for service providers as well as the quality of services for users.

Based on lessons learned from initial SMA, users and service providers will determine whether national deployment is beneficial.

New runway incursion reduction capabilities will be implemented to help reduce the possibility of traffic conflicts; this includes additional surveillance, ATC tools, signage, lighting, new procedures, and increased training. The installation of a new surface surveillance/conflict detection system for additional airports that do not have ADSE/AMASS is expected to begin.

The first increment of local data-sharing services will enable all intrafacility systems to share common data.

24.1.3 Airport Traffic Control Tower Architecture Evolution—Step 3 (2006–2007)

This step begins the enhancement of the local information services in preparing for the NAS-wide information network, upgrades the TDWs, and initiates a next-generation SMA called a surface management system (SMS) (see Figure 24-5).

As local legacy systems are replaced or new systems developed, commercial data base management systems will be used where applicable and models of information for all systems will be based on managed data standards. The NAS-wide information network will evolve from local information data exchange to interfacility information exchange. Structured data will be accessible by external applications. The NAS information network will provide information to both users and controllers, taking into account necessary security policies and precautions.

High-activity towers will begin to receive an upgraded TDW that will accommodate selected additional data entry and display. The TDW will be used to display a mixture of terminal and surface information (see Section 23, Terminal). Tower controllers will be able to monitor both surface

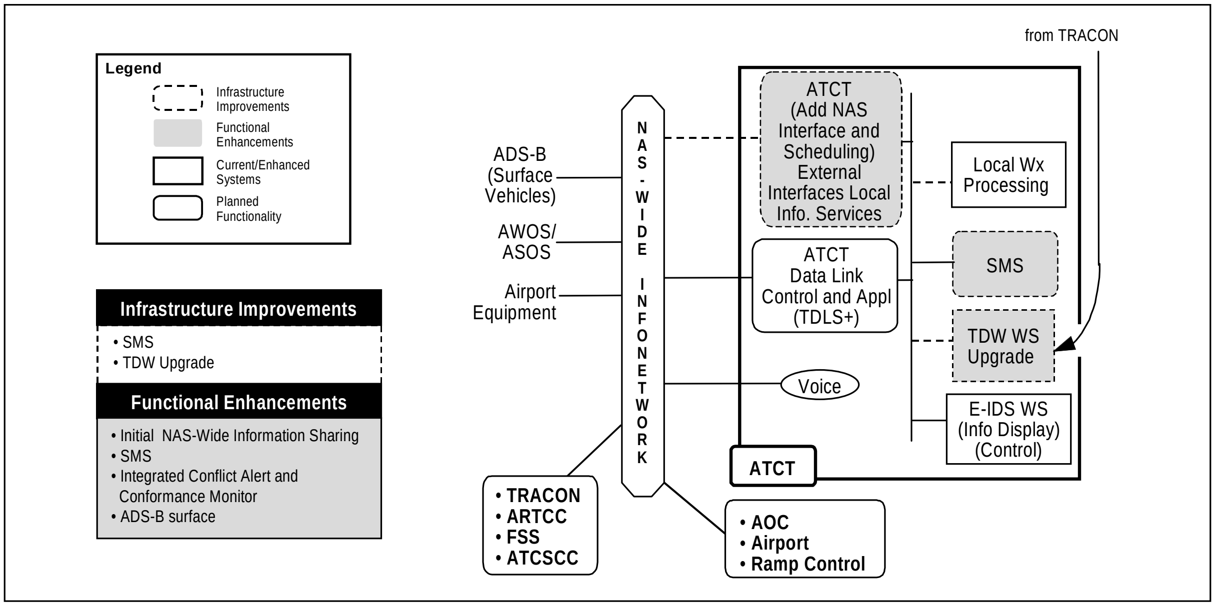

Figure 24-5. Airport Traffic Control Tower Architecture Evolution—Step 3 (2006–2007)

and airborne traffic via integrated surveillance displays, configurable to the particular needs of the control position in the tower. Surface traffic will be displayed with a perimeter "look-ahead" for airborne traffic. Airborne traffic may be displayed with an inset for runway and adjacent taxiway activity.

A next-generation SMS will be deployed at selected high-activity airports. The exact features of SMS have yet to be defined, but it will include enhanced decision support to aid movement sequencing and scheduling in conjunction with TRACON operations.

The tower data link services (TDLS) will automate tower-generated information for transmission to aircraft via data link. The TDLS interfaces with sources of local weather data and flight data and provides PDCs and D-ATIS.

24.1.4 Airport Traffic Control Tower Architecture Evolution—Step 4 (2008–2015)

Early in this step, airports will have access to the NAS-wide information network to provide complete data connectivity among service providers, airline operation centers (AOCs), airport operators, and airport emergency centers (see Figure 24-6).

In the far term, ATCT surveillance will be provided by the all-digital system that was developed from the terminal surveillance data processor (SDP), which was described in Section 23, Terminal. Surveillance data from all sensors and systems covering airborne and surface vehicles will be fused, creating a track file for use by all automation functions. This front-end surveillance processor function will produce a synergetic surveillance data base, permitting automation functions that use "best quality" surveillance data for specific purposes.

The introduction of the Local Area Augmentation System (LAAS) for the Global Positioning System (GPS) and automatic dependent surveillance (ADS) data will greatly increase the accuracy of position data from both surface vehicles and aircraft traffic

The enhanced SMS will be fully integrated into the automation platform provided by the TDW upgrade for surface planning and monitoring. The SMS will contain information on environmental and operational conditions at the airport and send updates to the NAS-wide information network. The SMS and NAS-wide information network inform service providers of all arrival, surface, and departure schedules. The systems also interface with surface and airborne surveillance information, flight information, weather, and traffic management systems. This data sharing at the airport allows service providers to coordinate local operations with airline ramp and airport operators, improving airport operations. SMS will integrate

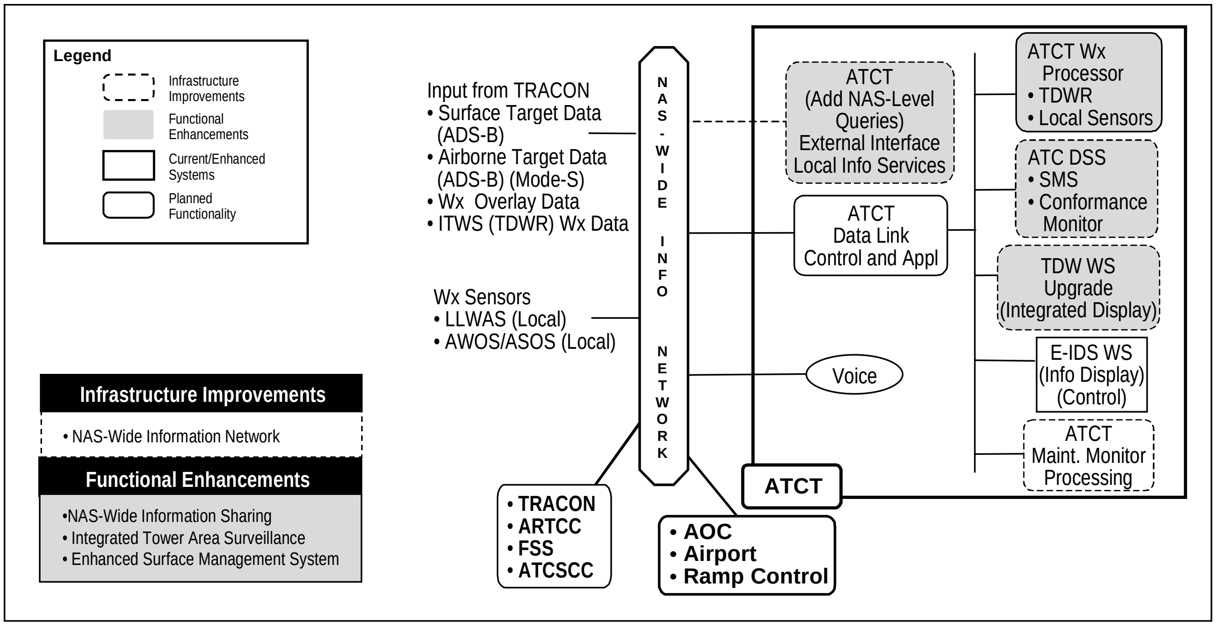

Figure 24-6. Airport Traffic Control Tower Architecture Evolution—Step 4 (2008–2015)

planning functions, providing an expanded conformance monitoring and probe function that could data-link an alert directly to the cockpit.

All these automation systems will support monitoring, routing, and timing of aircraft surface movement and will be fully integrated with the flight data, traffic management, and local weather system functions. Surface map displays of automated surface movement safety and guidance information will be available in both the tower and cockpit to enhance coordination.

Flight data processing will be integrated with real-time tower operations. Conflict detection will be available for integrated terminal and surface operations; the information will be displayed in towers and TRACONs. Finally, improved metering, sequencing, and spacing aids will be used for arrivals and departures, which will increase airport capacity and improve surface operations.

Data link services in the tower/airport domain will evolve from services developed for the en route and terminal domains. Thus, until this step, data link services continue to involve only the uplink of information to aircraft and require no reply from the flight deck.

As data link evolves, the capability for controller-pilot dialogue to communicate strategic and tactical air traffic service messages that are currently conveyed by voice will be implemented and may be transitioned to the tower domain depending on their success. A ground-based processor will receive a downlinked request from the flight deck, compile the requested information, and uplink it to the aircraft for display. Next, data link will facilitate the downlink of weather and aircraft state-and-intent information to improve the prediction capabilities of decision support and weather systems.

24.2 Summary of Capabilities

The summary of the tower/airport traffic handling capabilities is depicted in Figure 24-7. These capabilities will be enhanced by removing constraints to aircraft movement, from gate pushback to the runway and from landing rollout to the gate. Airport surface movement operations and information exchange coordination will be facilitated by the expanded use of data link capabilities and the incorporation of cockpit avionics (e.g., GPS/automatic dependent surveillance broadcast (ADS-B)) to display airport surface position and other traffic. This will provide cockpit crews with improved situational awareness and conflict advisories so that they can conduct all-weather, low-visibility taxi operations. The NAS will also feature enhanced decision support tools designed to improve planning of airport surface movement, balancing runway arrival/departure demand, and

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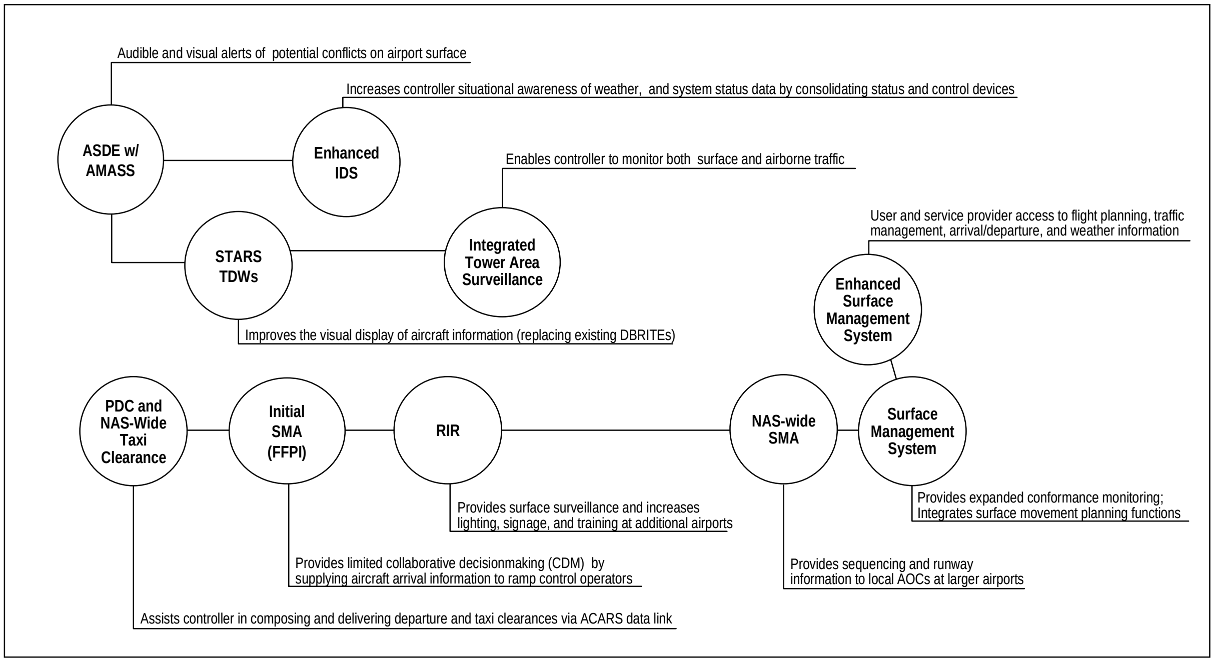

Figure 24-7. Tower and Airport Surface Capabilities Summary

sequencing of aircraft by performance type to the departure runway.

The integration of tower/surface automation with the terminal arrival/departure automation systems will also help relieve congestion at the runway threshold by integrating runway demand with operational capability to handle the airborne and surface traffic load.

24.3 Human Factors

Human factors efforts in developing prototypes, conducting simulations, assessing human-system performance against baselines, integrating workstations, and training for new systems include:

- Designing new automation interfaces for tower controller traffic management tasks, such as monitoring, routing, and timing surface movement
- Establishing methods and procedures for new enabling technologies, such as voice recognition and synthetic voice, to reduce controller head-down time and facilitate routine repetitive tasks
- Designing the human interface for integrated displays of information related to weather, surface movement, arrival and departure management, and system status
- Integrating automated operations related to flight data processing, tactical conflict detection, and improved spacing and sequencing
- Increasing efficiency of controller tasks, such as departure clearance services, flight plan data access, and landing and taxi control operations
- Allocating roles and responsibilities for collaborative controller planning and decision-making under various system constraints and alternatives.

24.4 Transition

Figure 24-8 depicts the transition to the ATCT architecture. For a significant period, the current ATCT systems will be sustained. The E-IDS will be deployed to consolidate status and display devices in the tower cab. All high-activity towers will be equipped with IDS, followed by installation of IDS in moderate-activity towers. The high-activity towers will receive the upgraded TDW, which will integrate the platform for the majority of applications in ATCTs.

24.5 Costs

The FAA estimated costs for facilities and equipment (F&E), operations (OPS), and research, engineering, and development (R,E&D) for the

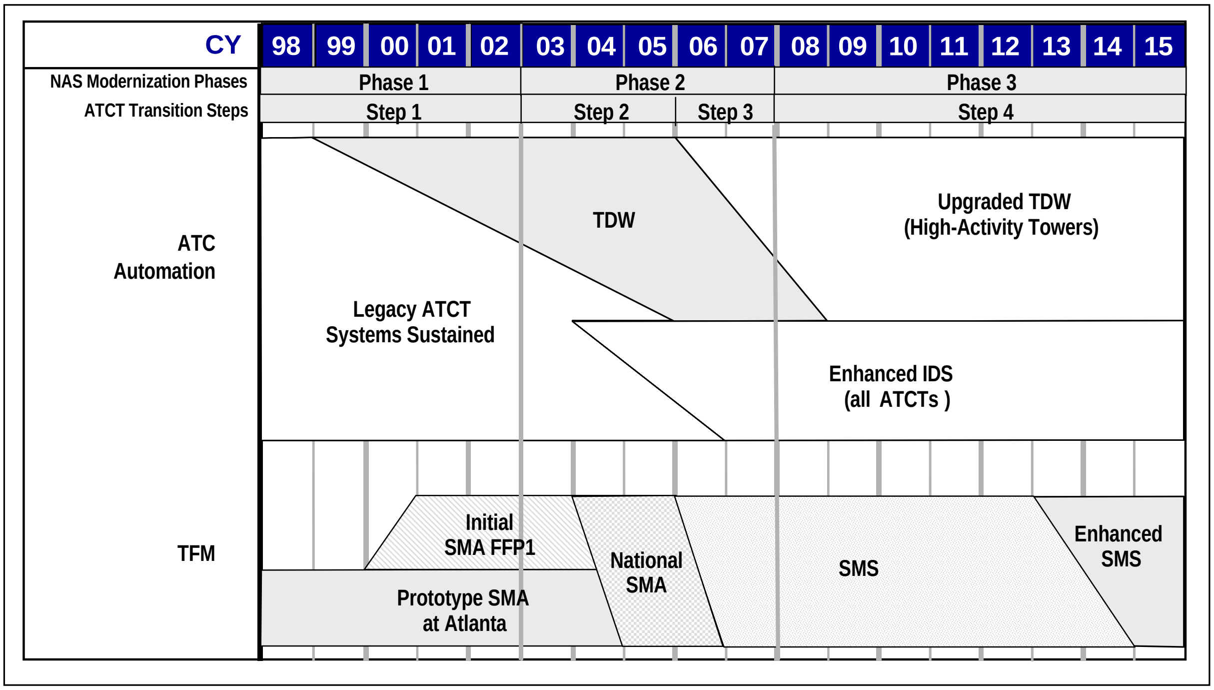

Figure 24-8. Airport Traffic Control Tower Architecture Transition

tower automation architecture from 1998 through 2015 are presented in constant FY98 dollars in-Figure 24-9. This excludes costs associated with DBRITE replacement in the STARS program (see Section 23, Terminal), LAAS landing systems (see Section 15, Navigation, Landing, and Lighting Systems), or weather systems (see Section 26, Aviation Weather).

24.6 Watch Items

A Tower and Airport Surface program (e.g., automation, information display system (IDS), TDWs) is needed. The ATCT enhancements are highly dependent on developments in other domains. The FAA recognized the need to assess its ability to implement and integrate the DSSs on the tower displays, and that there is yet to be any

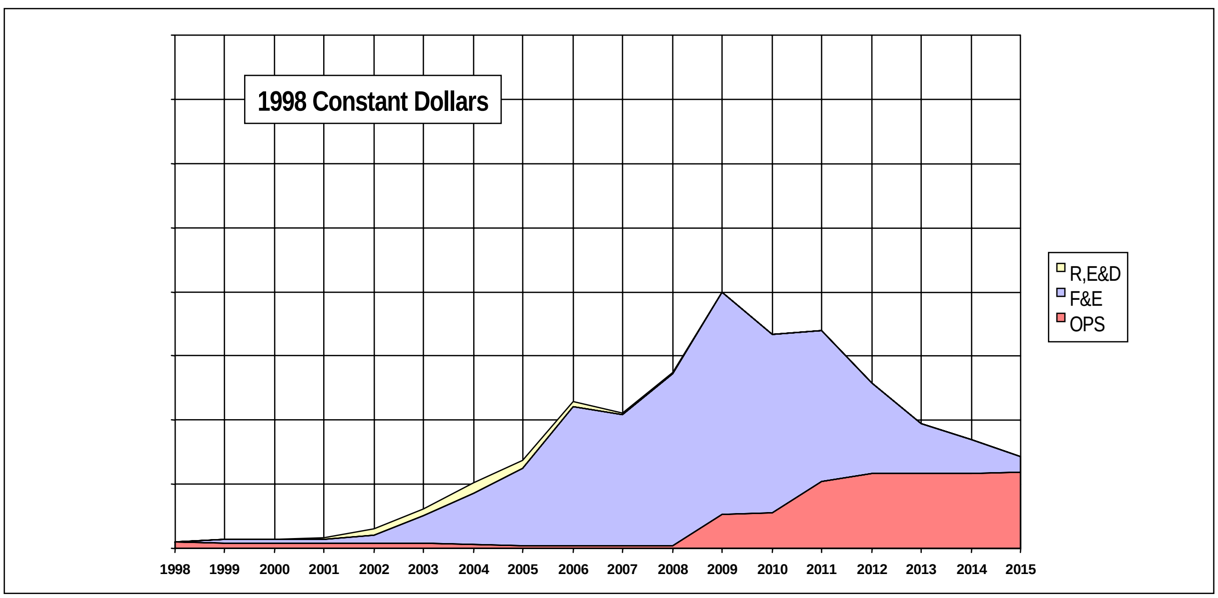

Figure 24-9. Estimated Airport Traffic Control Tower Automation Architecture Costs

commitment made to implementing these capabilities. Surface movement guidance and control require significant integration to provide the needed services without distracting from the need to keep most of a controller's workload focused on visually observing traffic.

25 FLIGHT SERVICES

FAA flight service stations (FSSs) provide accurate and timely aviation weather, aeronautical information, and flight planning assistance to commercial, general aviation (GA), and occasionally military pilots. Most military flight plans are entered into the NAS by military base operations (MBO) interfaces with FSSs. Disseminating this information is critical to safe and efficient operation of the NAS. Functional enhancements include the following capabilities:

- Increase pilots' ability to access information via automation sources, both prior to flight and while airborne
- Enhance the ability of FSS specialists to utilize current information (i.e., notices to airmen (NOTAMs) and hazardous weather advisories) when briefing or assisting pilots
- Modernize communications while retaining in-flight voice services and associated infrastructure as a governmental function
- Provide access to a NAS-wide information network for obtaining and distributing flight-specific data and aeronautical information
- Provide interactive aids that improve the user's ability to execute flight plans, thereby facilitating a more collaborative role for users in obtaining NAS information, such as special use airspace (SUA) status, and traffic density
- Standardize domestic and international flight and weather information.

In the future, the responsibility for NAS flight services will be shared between the government and the private sector. Efforts are currently underway to further define the services provided by FSS specialists and the private sector.

25.1 Flight Services Architecture Evolution

Today, pilots can obtain services directly from an FSS via telephone or by using personal computers to obtain weather and preplanning services from commercial or FAA systems. A number of states and localities provide this arrangement via self-service kiosks, which provide remote, automated access to everyone, as well as convenient on-airport access by pilots. Commercial enterprises will continue to be active in providing preflight services (for a fee) in the near term. As pilots become more self-reliant, the number of specialist-provided, preflight transactions (briefings and flight plan filings) will decline. The rate of decline cannot be predicted, but GA use of direct user access terminal (DUAT) service has grown steadily. In addition, the trend for states to contract with commercial vendors to supplement FSS-provided services is likely to continue.

25.1.1 Flight Services Architecture Evolution—Step 1 (1998)

Currently, flight services are provided to pilots via any one of the 61 automated flight service station (AFSS) facilities or remotely via the DUAT service in the continental United States. Additionally, 14 manual FSS facilities are located in Alaska.

The flight service automation system (FSAS) Model 1 Full Capacity (M1FC) system was deployed in the late 1980s. The FSAS consists of:

- Two aviation weather processors (AWPs) that supply a uniform set of global flight planning and alphanumeric weather data
- Approximately 1,500 flight service position consoles used by FSS specialists
- User access to weather briefings and flight plan processing via DUAT service.

As the original FSAS system offered limited capabilities, it was later augmented with a graphic weather display system (GWDS) and the DUAT service to supplement pilot access to the information available in the FAA automation systems.

Current preflight and in-flight service functions include:

- Filing instrument flight rules (IFR), visual flight rules (VFR), and defense (military) visual flight rules (DVFR) flight plans
- Providing VFR flight following, and initiating and coordinating search and rescue (SAR) activities
- Providing broadcast messages
- Providing user access to weather briefings and flight plan processing via DUAT service

PART III

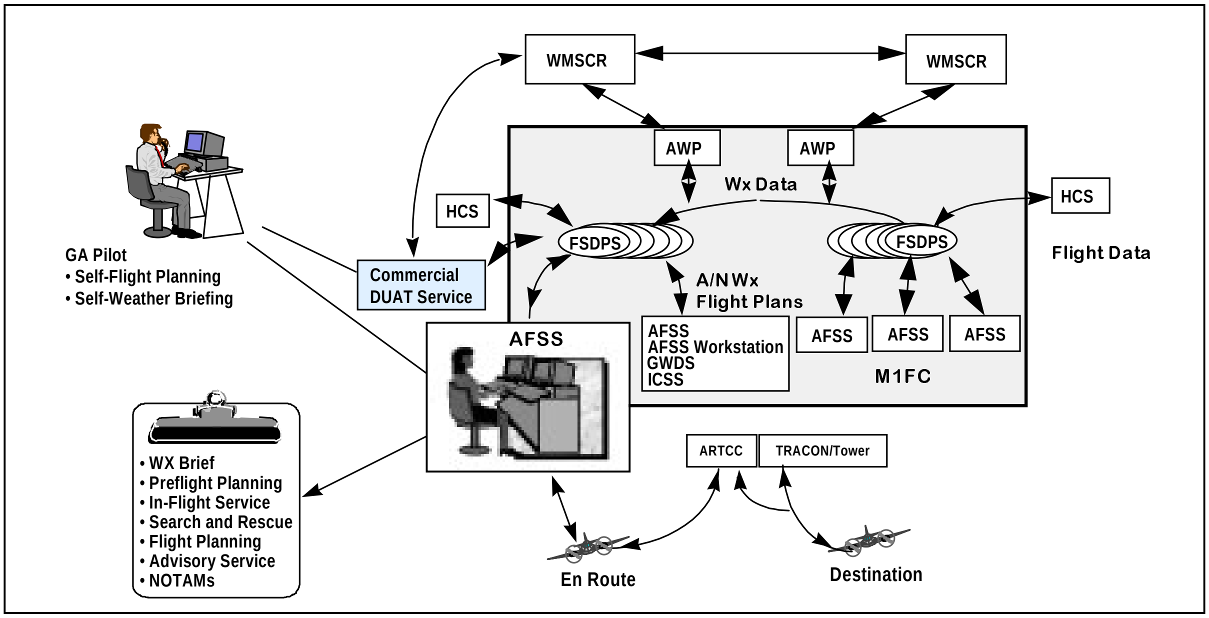

Figure 25-1. Flight Services Architecture—Step 1 (1998)

- Disseminating NOTAMs
- Processing and disseminating pilot reports (PIREPs)
- Providing emergency services
- Providing other services as requested.

Figure 25-1 depicts the current flight services architecture. The ensuing architecture discussion addresses changes within the FSAS structure.

25.1.2 Flight Services Architecture Evolution—Step 2 (1999–2005)

Almost immediately in Step 2, the Operational and Supportability Implementation System (OASIS), a new commercial-off-the-shelf (COTS)-based capabilities system, will replace the existing AFSS automation (i.e., FSAS). OASIS will allow pilots to self-brief and to file flight plans directly. For those pilots unable to self-brief or who require direct contact, flight service specialists will be available. OASIS will be provided as a leased service and includes a reliable, open systems compliant hardware and software system configuration. Figure 25-2 illustrates the near-term, Step 2 architecture for flight services.

OASIS contains significant computer-human interface (CHI) improvements that provide standardized products to both the specialist and the pilot. The existing FSAS display will be replaced with a graphical user interface, enabling automated information retrieval while enhancing processing and storage performance. Initially, OASIS provides greater coordination and checking of flight plans with the Host/oceanic computer system replacement (HOCSR).

The FAA is undertaking an initiative called Safe Flight 21 to demonstrate and validate an integrated set of capabilities leading to Free Flight. An overview of Safe Flight 21 is provided in Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone. Flight information services (FIS) transmits noncontrol information such as weather data, NOTAMs, and SUA information. Safe Flight 21 demonstration validations (DEMVALs) for FIS and weather services will involve specific operational improvements for different aircraft types operating at various altitudes under IFR and VFR flight plans. The DEMVALs will also include the impact of FIS/weather data link on air traffic control procedures, pilot-controller responsibility for severe weather separation, and collaborative decisionmaking. Weather support to Safe Flight 21 will be provided by the weather and radar processor (WARP) and OASIS and tailored in accordance with each DEMVAL.

As pilots become more self-reliant and depend less on direct contact, in-flight services (e.g., in-flight weather support, VFR flight following, and

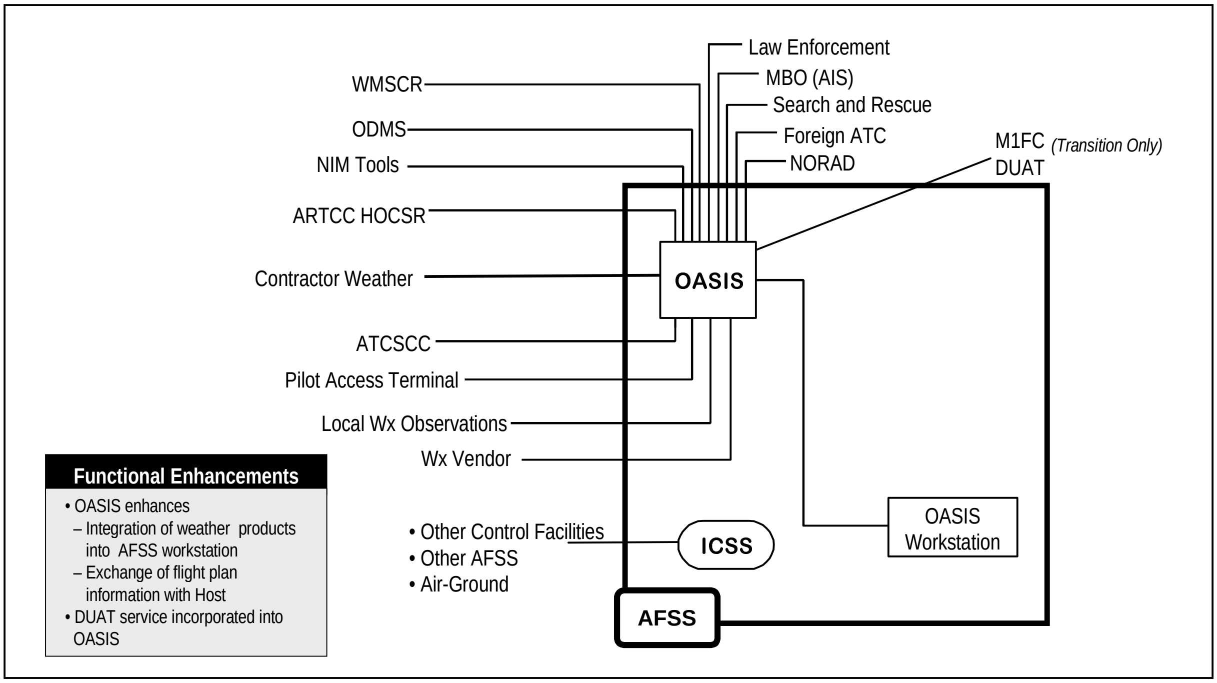

Figure 25-2. Flight Services Architecture—Step 2 (1999–2005)

search and rescue support) will ultimately become the principal focus of the flight service specialist.

Late in the period, enhanced local information sharing will be implemented in OASIS to provide data storage and data sharing according to the NAS-Wide Information Service (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

25.1.3 Flight Services Architecture Evolution—Step 3 (2006–2015)

Retrieval of information in AFSSs will be quicker as the ability to exchange information with other facilities matures by the middle of Step 3 (see Figure 25-3). In this step, flight plans will be replaced by the flight object (see Section 19 for additional details about the flight object). The flight object contains the pilot's known flight path or profile, the discrete identification code, and all information necessary to initiate SAR if needed. This information is available throughout the NAS. For aircraft equipped with satellite navigation systems and using ADS-B, the NAS-wide information network will have the capability to automatically identify a successful landing, close a flight plan inadvertently left active in the system, or provide last known position.

Access to and retrieval of flight planning information will be continuously available to users and service providers via the NAS-wide information network. The following information will be available:

- Current SUA status
- Current NAS infrastructure status
- Predictions of traffic density based on the current flight trajectories filed and active in the system
- Current or planned route structure revisions needed to alleviate demand imbalance or avoid hazardous weather.

By the middle of Step 3, flight service automation will be fully integrated into the NAS-wide information network (see Figure 25-3). Access to flight planning and flight filing information by users will be via this network. FSS specialists will provide information to aircraft in flight, as necessary, predominately via data link.

Connectivity between the AFSS and other facilities will migrate to the NAS-wide information network. The integrated communications switching system (ICSS) infrastructure will transition to digital technology and the voice switch replacement system (VSRS). Air-ground voice commu-

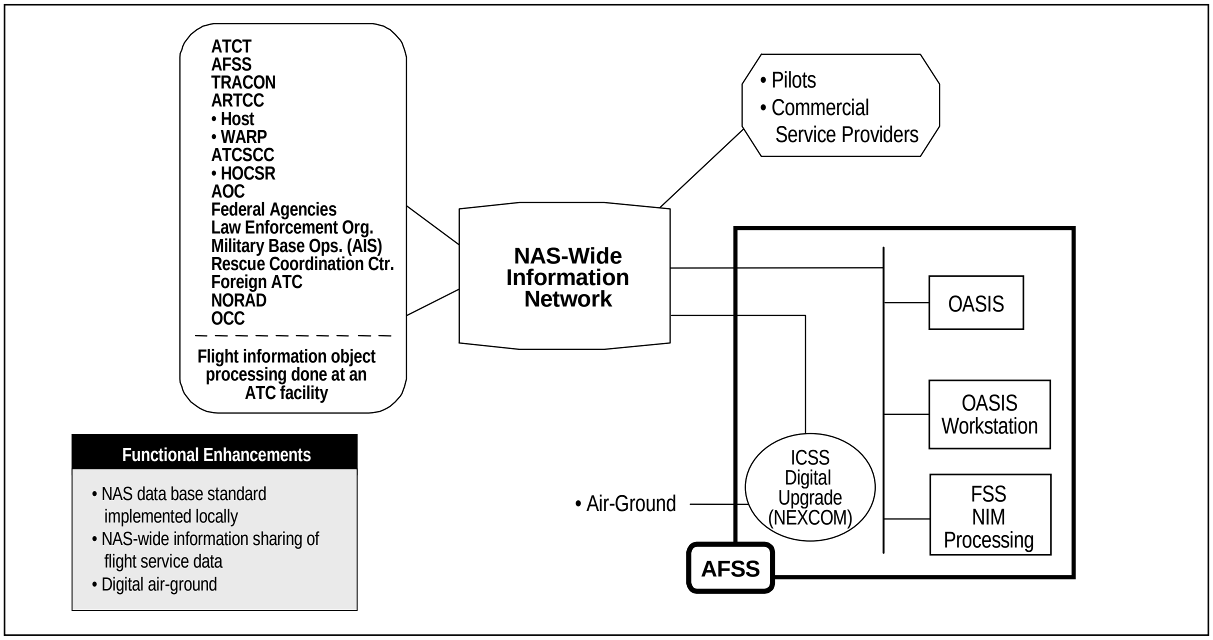

Figure 25-3. Flight Services Architecture—Step 3 (2006–2015)

nications will be provided via the next-generation air-ground communications system (NEXCOM) operating in analog mode. Transition to digital mode will depend on user equipage (see Section 17, Communication).

As the flight plan is formulated, the planner will reference the network data base for information about current and predicted weather conditions, traffic density, restrictions, and status of SUAs. When the flight plan is filed, it is automatically checked against actual and predicted NAS conditions. Potential problems will be displayed automatically to the planner or user and flight plan alternatives will be provided.

During the middle of Step 3, flight service research efforts will be implemented as OASIS is upgraded. These tools include decision support systems (DSSs) to assist preflight planning and suggest alternate routes in the event of hazardous weather, conflicts with SUA use, and in response to NOTAMs and other NAS constraints. Research initiatives realized during this period involve improvement of SAR support services by incorporating aircraft identification and position received from an emergency locator transmitter (ELT), referenced to the Global Positioning System (GPS) into NAS data bases, enhancing SAR support. Other research efforts will help determine the criteria for implementing the time-based trajectory flight profile (flight object) that will eventually replace the flight plan.

25.2 Summary of Capabilities

OASIS replaces obsolete FSAS equipment and software. It also incorporates the functionality of DUAT service and GWDS. Commercial enterprises will likely continue to be active in providing preflight services for a fee.

With full implementation of the NAS-wide information network, NAS users everywhere can access distributed data bases of weather, NOTAMs, SUA information, and the flight object. By virtue of making the distributed data bases readily accessible, this network greatly enhances various FSS functions such as route de-conflicting, self-briefing, and SAR services. In this flight services architecture, users and providers rapidly acquire any information they need, and flight services become a shared responsibility of the flight service specialist, the pilot, and commercial vendors. Figure 25-4 summarizes the evolution of flight services capabilities.

25.3 Human Factors

Flight service functions are not expected to change dramatically as new information automation systems are put into service. However, there

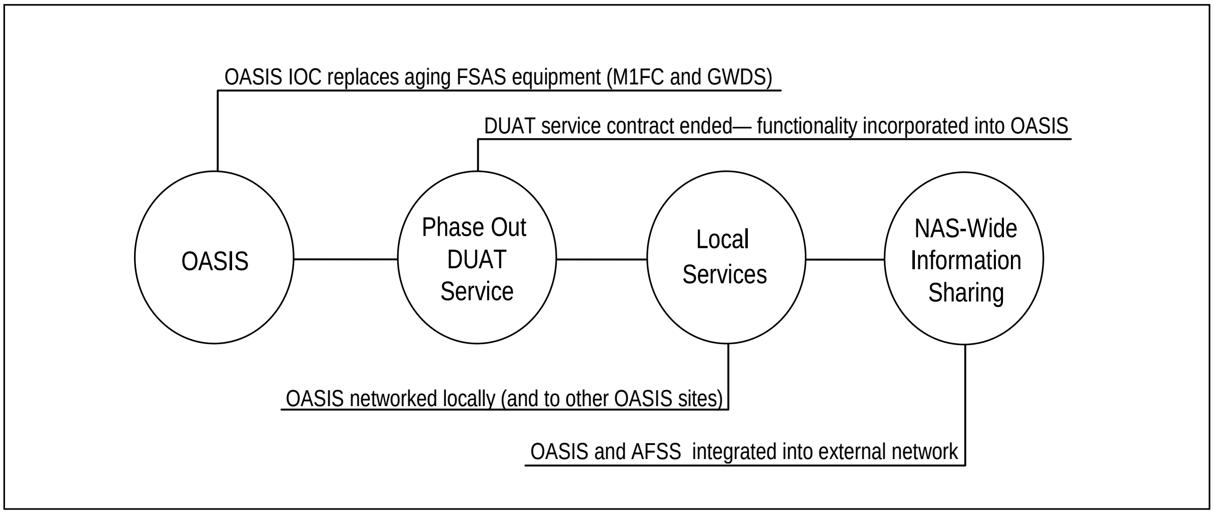

Figure 25-4. Flight Services Capabilities Summary

will be a change in the specialists' focus toward providing services to those without direct access and those needing additional assistance. While the introduction of OASIS is expected to improve the human interface and eliminate many of the problems encountered with the current system, future systems will provide flight service specialists and users with enhanced situational awareness by increasing the quality of service provided. The human factors effort will ensure that specialists have the required information displays and distribution tools, training, and procedures to enhance flight services. This effort will focus on:

- Improving automation capabilities for pilots to receive and use critical flight and weather information from multiple NAS facilities, especially when airborne
- Designing information displays and distribution methods and procedures to increase pilots' (and flight service providers') situational awareness and interpretation of available data
- Coordinating human factors standards for display and distribution among international elements to harmonize aeronautical information, flight trajectory data, and traffic density
- Conducting simulations to devise procedures (and training) for real-time trajectory information updates for improved traffic prediction and management

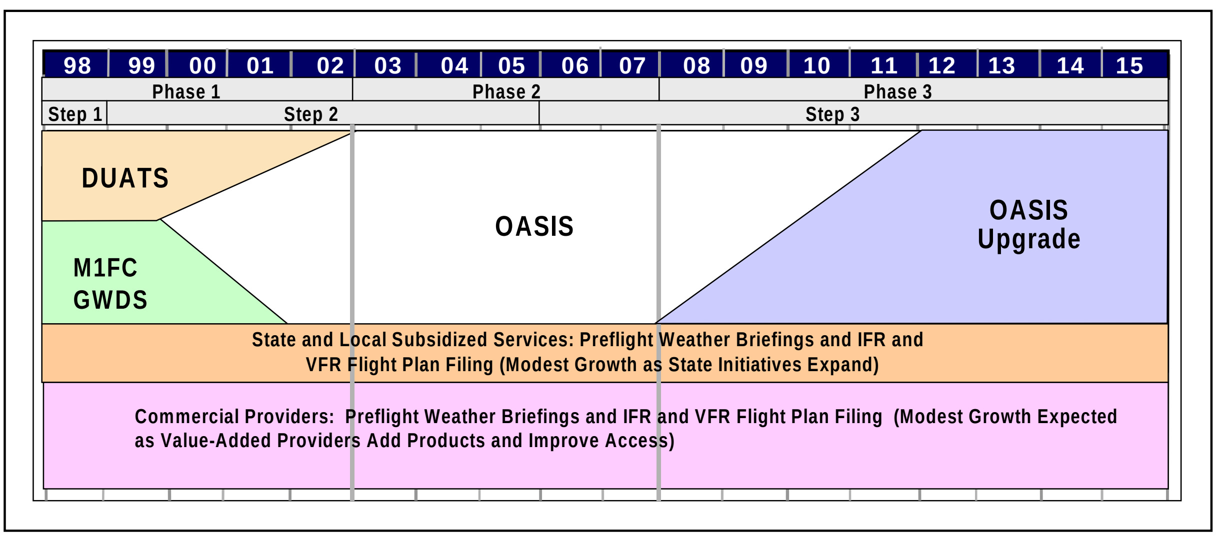

Figure 25-5. Flight Services Transition

PART III

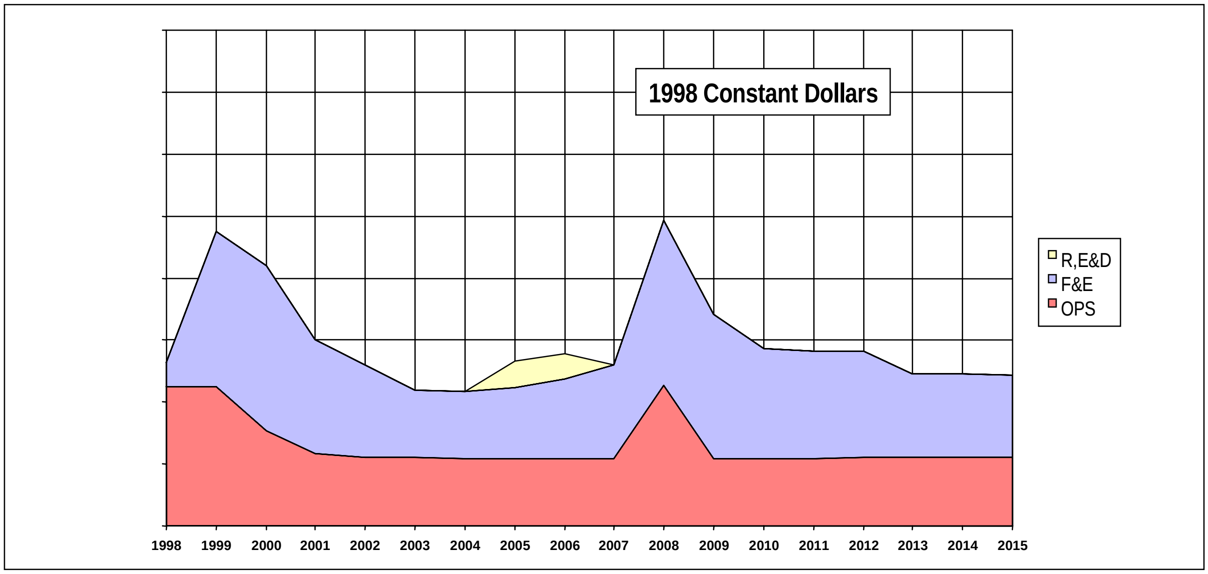

Figure 25-6. Estimated Flight Services Automation Costs

- Designing error-tolerant decision support tools and interactive aids that facilitate user collaboration in obtaining and using NAS flight planning and flight profile information.

25.4 Transition

The flight services transition is depicted in Figure 25-5. The major transition milestones are:

- Existing M1FC/GWDS is replaced by OASIS.
- DUAT service is phased out as its functionality is incorporated into OASIS.
- Local information services are enhanced.
- FSAS is fully integrated into the NAS-wide information network.

25.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for flight services from 1998 through 2015 are presented in constant FY98 dollars in Figure 25-6.

25.6 Watch Items

Implementation of OASIS will enhance pilots' ability to self-brief and file flight plans directly, which will require a reevaluation of the roles and responsibilities of FSS specialists.

26 AVIATION WEATHER

Weather information services are critical to NAS safety and efficiency. According to the National Research Council (NRC) report[1] on Aviation Weather Services, from 1988 to 1992 one-fourth of all aircraft accidents and one-third of fatal accidents were weather-related. The 1996 Nall Report[2] states that 69 percent of all weather-related general aviation (GA) accidents resulted in fatalities. The 1997 Aviation Capacity Enhancement Plan reveals that from 1992 to 1996, adverse weather was a major factor affecting NAS capacity, accounting for 72 percent of system delays greater than 15 minutes.

Aviation weather capabilities in the NAS must undergo major changes. The changes will convert today's weather architecture—consisting of separate, stand-alone systems—to one in which future weather systems are fully integrated into the NAS under the weather server concept (single-sourced data shared with all systems). The weather architecture evolves further as it progresses from a "weather server" concept (serving primarily the en route and terminal domains) to one that supports all NAS users, with the implementation of the NAS-wide information service. Integration into this information exchange allows the weather architecture to exploit communications enhancements and provide near simultaneous delivery of weather data and products to both users and service providers.

As a result, NAS providers and users receive the same hazardous weather information (with system-tailored depiction) *simultaneously*, enhancing common situational awareness. This facilitates collaborative decisionmaking for traffic flow managers, controllers, flight service specialists, and pilots. This is accomplished by two new weather systems that convert multiple sources of "raw" weather data into meaningful information: the integrated terminal weather system (ITWS) and the weather and radar processor (WARP). These systems act as weather servers providing information to other subsystems and users. In addition, communications enhancements (i.e., flight information services (FIS) data link) will improve the data exchange between the ground and the cockpit.

26.1 Weather Architecture Evolution

The NAS weather architecture optimizes the capability to collect and process weather data, provide current and forecast conditions of hazardous and routine weather, and disseminate that information in text and/or graphical formats to all NAS users and service providers. NAS users include pilots who receive preflight and in-flight weather information, flight planners, air traffic control (ATC) specialists, airline and vendor meteorologists, and airline dispatchers. Service providers include ATC personnel, traffic flow managers, and flight service specialists. This capability enhances safety and capacity by promoting common situational awareness.

The NAS weather architecture features an evolution to fully integrated systems enhanced by the maturation of the NAS-wide information service (see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing).

NAS weather architecture systems are categorized as either (1) *sensors* and/or *data sources* or (2) *processing and display systems*. In some cases, a system will process and display data and also be the source of weather data for other NAS systems (e.g., ITWS). The four-step evolutionary process for implementing the NAS weather architecture is discussed in Sections 26.1.1 through 26.1.4.

26.1.1 Weather Architecture Evolution—Step 1 (1998)

The current weather architecture is depicted in Figure 26-1. This diagram and the following weather architecture diagrams are generic depictions of NAS facility/subsystem connectivity. In the upper left section of the diagram are the

1. "Aviation Weather Services, A Call for Federal Leadership and Action," National Aviation Weather Services Committee, Aeronautics and Space Engineering Board, Commission on Engineering and Technical Systems, and National Research Council Report, National Academy Press, Washington, D.C., 1995, p 10.
2. *Nall Report, Accident Trends and Factors for 1995,* The Aircraft Owners and Pilots Association Air Safety Foundation, 1996, p. 13.

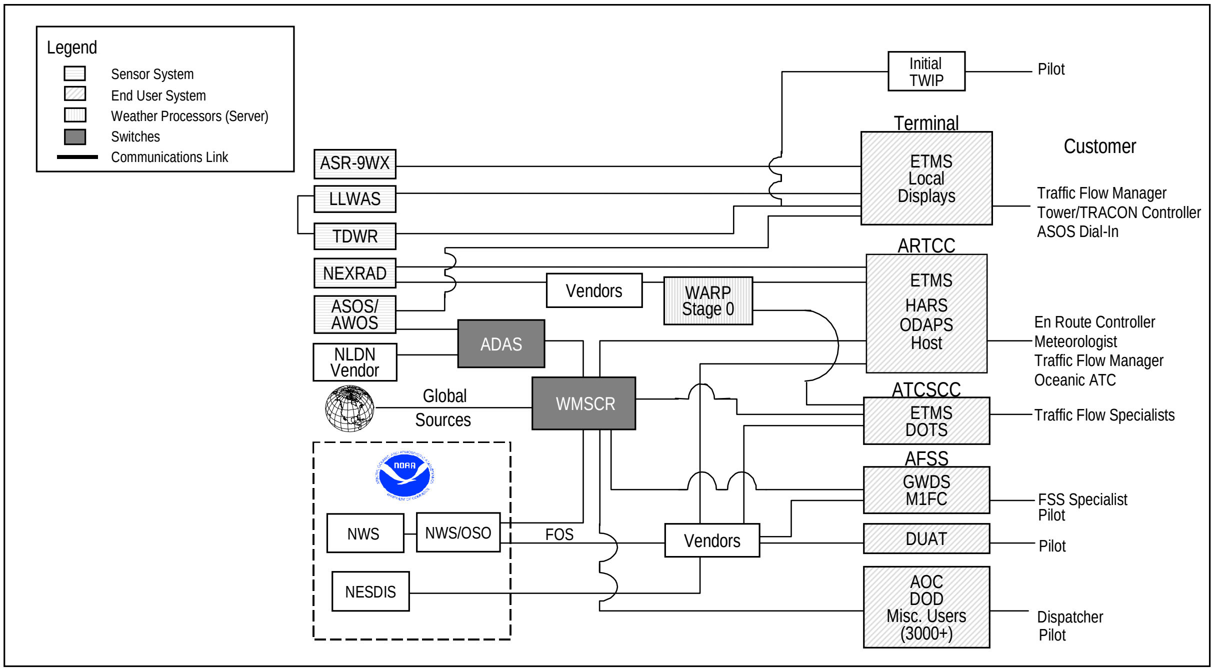

Figure 26-1. Weather Architecture Evolution—Step 1 (1998)

weather sensors that collect the raw data. At the lower left section of the diagram are the outside agencies that provide the majority of weather information to the NAS—the National Weather Service (NWS) and the National Environmental Satellite, Data, and Information Service (NESDIS). The NWS and NESDIS are offices of the National Oceanic and Atmospheric Administration (NOAA). In the center of the diagram are the weather switches, which the FAA uses to transport data. The weather processors are also included in the center section. Finally, on the right side of the diagram is the ultimate user of the data. In the diagrams, the flow of weather data is from left to right as it moves into and through the NAS.

Sensors and Data Sources

Weather data are obtained from ground-based sensors, aircraft sensors, and commercial vendors. Surface observations are generated manually by observers or automatically by the automated weather observing system (AWOS) and automated surface observing system (ASOS). The AWOS data acquisition system (ADAS) collects, processes, disseminates, and archives observations from AWOS and ASOS for local and national distribution. Using data from the National Lightning Detection Network (NLDN), ADAS generates and sends lightning activity messages to AWOS and ASOS for reporting use.

The next-generation weather radar (NEXRAD) provides a variety of weather data, in the areas covered, including layered radar reflectivity data associated with severe weather such as tornados and hail, areas of precipitation, wind speed and direction, and turbulence.

The ground-based low-level windshear alert system (LLWAS) and the terminal Doppler weather radar (TDWR) detect localized windshear phenomena such as microbursts, while windshear detection systems on commercial jetliners provide airborne detection. In the terminal area, thunderstorm information can be inferred from TDWR and by primary airport surveillance radar (ASR), as well as by NEXRAD. In the en route environment, weather radar data from NEXRAD, primary air route surveillance radar (ARSR), and NLDN are used to provide this information.

NOAA support includes observations (surface and aloft), aviation advisories such as significant meteorological information (SIGMET) and airmen's meteorological information (AIRMET), terminal and en route forecasts, radar data, and satellite data. The National Center for Environmental Prediction (NCEP) is a collection of NWS centers that are responsible for atmospheric model development and forecast output. NCEP models provide analyses of current weather and forecast weather parameters such as wind and temperatures aloft, which are required by NAS users. The NWS distributes the data to vendors who provide these data to the FAA.

The NWS's Aviation Weather Center (AWC) uses a computer model to generate forecasts of aviation hazards such as icing. The AWC works closely with both the FAA Aviation Weather Research (AWR) Program and air traffic operations to improve forecasting tools. The AWC's forecasts of aviation-impact variables (icing, turbulence, and convective activity) mitigate the effect of hazardous weather on the NAS. A large portion of weather data used within the NAS is produced or collected by NOAA (i.e., NWS and NESDIS). Additionally, most third-party weather products find their origins in NWS-provided data and models.

The FAA uses terminal weather information for pilots (TWIP) to provide commercial pilots with direct access to limited weather information via the aircraft communications addressing and reporting system (ACARS) data link. This enables pilots of equipped aircraft to view a rough depiction of hazardous weather that is similar to the ones displayed to the tower and the terminal radar approach control (TRACON) controllers, greatly improving common situational awareness. Currently, TWIP is available only from TDWR sites.

Processing and Display

Weather information is processed and displayed in the various ATC facilities through separate weather systems. In air route traffic control centers (ARTCCs), these include the WARP Stage 0 and the NEXRAD principal user processor, which are used by meteorologists in center weather service units (CWSU) and traffic management units. In control towers and TRACONs, information from TDWR, LLWAS, and ASOS are usually provided on separate displays. Some integration of weather data into automation systems currently exists as the host computer processes ARSR weather data that are displayed in two intensity levels to en route controllers (see Section 21, En Route). Additionally, the automated radar terminal system (ARTS) displays ASR reflectivity data to TRACON and tower controllers (see Section 23, Terminal). Three terminals (Dallas-Ft. Worth, Memphis, and Orlando) currently have an ITWS prototype. National implementation of ITWS will begin in Step 2, providing short-term forecasts of terminal-impacting weather to controllers in TRACONs and towers.

At the Air Traffic Control System Command Center (ATCSCC), weather data are obtained from the aircraft situation display (ASD), NEXRAD, and command center WARP briefing terminals. Flight service specialists use the flight service automation system (FSAS), consisting of the Model 1 Full Capacity (M1FC) (see Section 25, Flight Services) plus the interim graphic weather display system (GWDS).

The weather message switching center replacement (WMSCR) is the primary NAS interface with the NWS telecommunications gateway (NWSTG) for the exchange of aviation alphanumeric and limited gridded weather products. WMSCR collects, processes, stores, and disseminates aviation weather products to major NAS systems, the airlines, and international and commercial users.

WMSCR also provides storage and distribution of domestic notice to airmen (NOTAM) data and retrieval of international NOTAMs through the Consolidated NOTAM System. WMSCR receives weather and NOTAM information from the DOD via the Automated Weather Network (AWN); severe weather information from AWC; observations from ADAS and the U.S. Air Force's automated weather information distribution system (AWIDS); international data via the aeronautical fixed telecommunication network (AFTN); and weather information from WARP and FSAS through the aviation weather processor. The WMSCR is also an integral part of the operational alphanumeric product backup for the NWS's automation of field operations and services (AFOS) communications network when the NWSTG is nonoperational.

26.1.2 Weather Architecture Evolution—Step 2 (1999–2002)

The weather architecture completes the deployment of two major systems during this time period, WARP and ITWS (see Figure 26-2). WARP will undergo software upgrades and produce re-

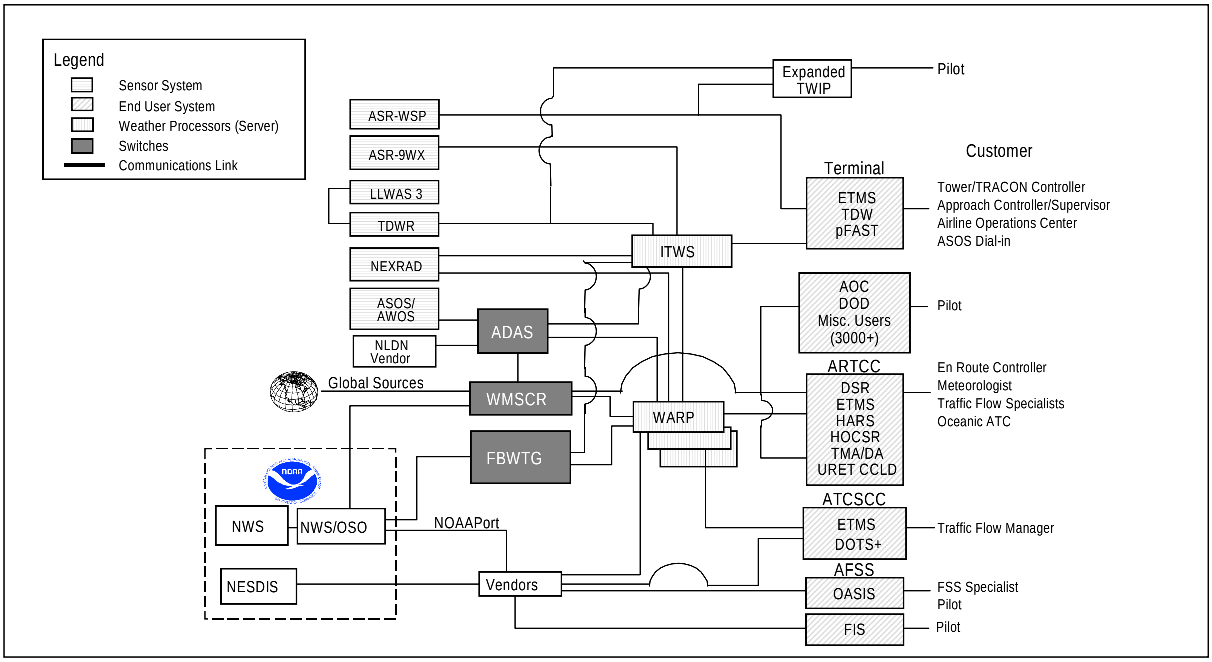

Figure 26-2. Weather Architecture Evolution—Step 2 (1999–2002)

gional and national mosaics of NEXRAD data. These mosaics will be displayed on display system replacements (DSRs) to controllers. WARP will also interface with the Operational and Supportability Implementation System (OASIS) and NAS automation systems, such as the User Request Evaluation Tool core capability limited deployment (URET CCLD) and the Center TRACON Automation System (CTAS) traffic management advisor (TMA). ITWS will be implemented during this period and provide enhanced terminal weather data forecasts to tower and TRACON personnel, as well as to NAS automation systems at 45 TDWR-equipped airports. ARTCC traffic managers will have an ITWS situation display enabling them to track storm activity at major airports and to facilitate coordination with the TRACONs and major hubs.

Other changes include the following: conversion of the NEXRAD radar product generator (RPG) to an open systems architecture; implementation of the FAA bulk weather telecommunications gateway (FBWTG); deployment of OASIS; and fielding of the airport surveillance radar-weather systems processor (ASR-WSP). ASOS and the ASOS Lightning Detection and Reporting System (ALDARS) deployment will be completed. TDWR upgrades include improvements to gust-front algorithms and equipment modifications.

As part of the NAS modernization schedule, the FAA will implement Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) as a risk-mitigation effort for subsequent national deployment of various automation systems designed to provide user benefits. WARP will support URET CCLD by providing forecasts of gridded wind and temperature data fields for trajectory calculations. Other FFP1 CCLD automation systems requiring weather data include the CTAS pFAST used by terminal controllers and traffic managers, and the TMA used by en route controllers and traffic managers. WARP Stage 3 implementation will be accelerated to provide this support.

As part of the FAA's flight information services (FIS) policy, the FAA will approve the basic weather data that a commercial service provider will provide to the cockpit. FIS provides the weather information needed by pilots to operate safely and efficiently. The National Aeronautics and Space Administration (NASA) and industry are engaged in joint research to provide "weather-in-the-cockpit." NASA will expend considerable research funds to develop aviation weather information systems to provide current data to airline and general aviation aircraft.

Sensors and Data Sources

The FAA will continue to obtain weather data from internal and external sources in Step 2. Current FAA sensors will be upgraded or replaced for sustainment. Airborne observations will improve as the airlines equip additional aircraft with weather sensors and increase the number of parameters reported (such as humidity and turbulence). NOAA will be the source of various data, including gridded forecast data from the NCEP (i.e., the Environmental Modeling Center (EMC) and the AWC) satellite data from NESDIS, as well as forecasts and observations from NWS Weather Forecast Offices. Some "value-added" products continue to be provided by vendors. The WMSCR continues to receive and transmit much of the alphanumeric weather information.

The FAA upgrades the basic weather sensors, leading to improved reliability, increased accuracy, and superior maintainability. An example of this refinement is the NEXRAD system upgrade. The NEXRAD network is upgraded to an open systems architecture with new hardware, software, and a modular configuration. The upgrade to the NEXRAD radar product generator (RPG) increases processing capabilities and accuracy and improves both reliability and maintainability. The upgraded system incorporates more complex algorithms. As science advances its understanding of meteorological processes that affect aviation, new products and services will be added to NEXRAD. ASOS will receive sensor and processor upgrades, thereby enhancing its capabilities.

The AWC disseminates forecasts of weather affecting aviation operations to the NAS in a gridded format. This gives NAS systems the capability to display aviation-impact variables, such as icing, in a format that is advantageous to users. For instance, a SIGMET report will no longer be available only in text format with an area location, but will also be provided in gridded data fields. This allows the location and extent of the significant (or hazardous) weather to be displayed graphically in four dimensions (including time). The AWC also provides forecasts of convective activity, icing, turbulence, and AIRMETs as gridded data fields.

There are a number of developmental projects sponsored by the AWR Program that are ready for implementation during this time period.

Processing and Display

Within the weather architecture, ITWS and WARP will function as NAS weather servers—WARP in the en route domain and ITWS in the terminal domain. As weather servers, WARP and ITWS "ingest" NWS computer model output, as well as acquire and process data from sensors such as the NEXRAD and TDWR.

These servers then generate and disseminate weather products to the NAS automation systems, such as CTAS TMA and enhanced traffic management system (ETMS). These systems use 3-dimensional wind and temperature forecasts, as well as convective weather data, to project activity and traffic flow and to allow for a more efficient use of airspace. Wind forecasts are used by URET CCLD to facilitate sequencing of air traffic by en route controller teams.

ITWS will be deployed by the end of Step 2. ITWS improves safety by providing a windshear and microburst prediction capability in the terminal area and improves management of runway resources when convective storms and gust fronts are present. Terminal controllers and traffic managers can more efficiently sequence aircraft in and out of terminal airspace by using wind shift predictions.

ITWS provides information on significant weather associated with severe storms and facilitates routing aircraft around hazardous weather by processing data from LLWAS-3, TDWR, airport surveillance radars (ASR-9), and NEXRAD. LLWAS-2 will continue to provide windshear and microburst information at those terminal sites (about 39) without TDWR and ASR-WSP. ITWS will process the six-level weather data from the ASR-9 to remove anomalous propagation and ground clutter. Removal of anomalous propagation and ground clutter from controller displays is essential, as it is often indistinguishable from actual weather. Initially, ITWS data will be displayed to terminal and tower controllers on separate displays. TWIP functionality will be moved to ITWS and enhanced by adding ITWS data to improve the accuracy of available weather information. TWIP will expand to include ASR-WSP sites at the end of this period.

As the en route weather server, WARP processes and displays NEXRAD data for use by ARTCC controllers and meteorologists. WARP creates a regional NEXRAD mosaic that is also provided to the ATCSCC and other facilities. WARP will incorporate NWS higher-resolution forecast data, which will improve forecast accuracy. Another benefit is the capability to provide controllers with time and position data on moving weather systems for traffic planning and flow control.

The new automation systems being deployed by the FAA require the NWS's improved, higher-resolution forecast data. The FAA is working closely with the NWS to develop the FBWTG. The FBWTG (see Figure 26-2) will enable the high-speed transmission of high-resolution, gridded weather forecasts between the NCEP and the NAS. The planned deployment of the first phase of the FBWTG is early in Step 2.

In addition to the current LLWAS and TDWR sensors, a weather system processor (WSP) enhancement for the existing ASR-9 will be deployed, adding a windshear and microburst detection capability. The ASR-WSP processes the six-level weather data and provides windshear and microburst products similar to TDWR.

ASR-WSP supports airports without a TDWR that need improved windshear and microburst detection capability. Like TDWR, ASR-WSP will provide a TWIP capability, thereby extending the area coverage of windshear systems providing data to pilots.

26.1.3 Weather Architecture Evolution—Step 3 (2003–2008)

Early in Step 3, WMSCR will be upgraded to improve capacity and enhance its capabilities. WARP will provide weather data to Multi Center TMA and DA. The major change in Step 3 will be the interface to the NAS-wide information network, which begins late in this step (see Figure 26-3); for more detailed information, see Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing. This network will allow weather systems in the terminal and en route environments to freely share data and products.

At this time, the FAA will make NAS status and existing weather data available to private data link service providers for the development of FIS products. Commercial providers may make basic

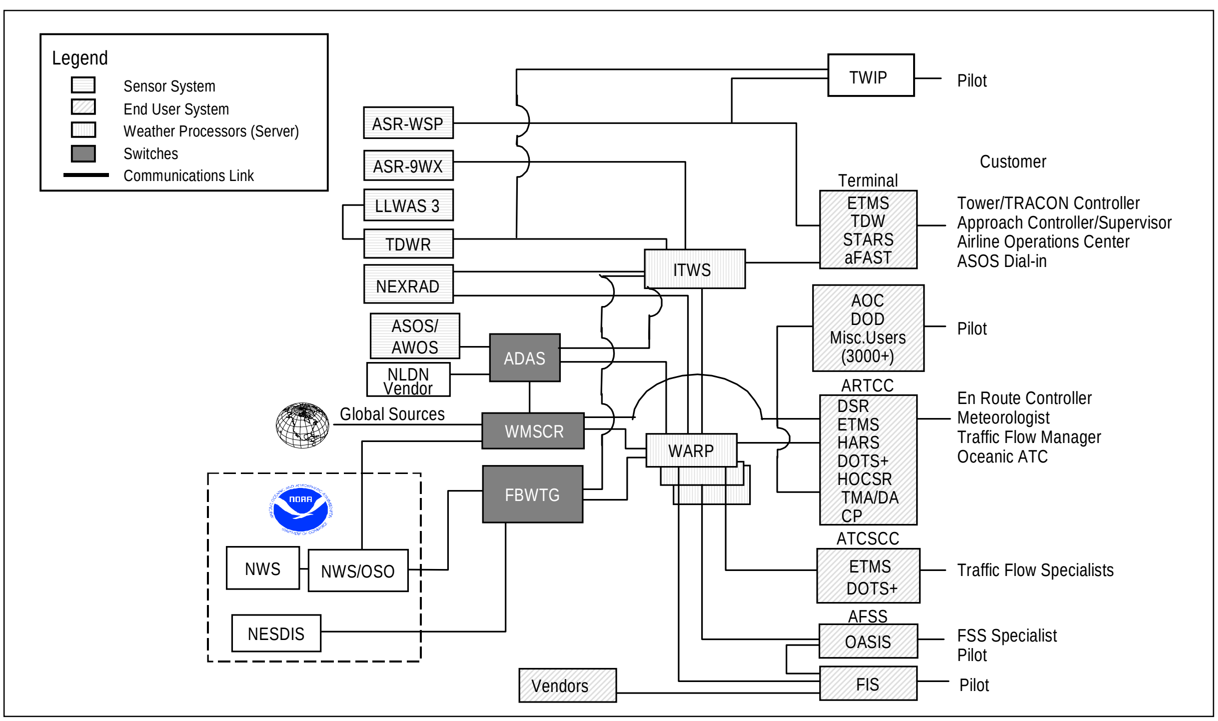

Figure 26-3. Weather Architecture Evolution—Step 3 (2003–2008)

FIS products available, at no cost to the government or the user, and may make "value-added" products available for a fee.

Sensors and Data Sources

NEXRAD will continue evolving to an open systems architecture through the upgrade of the radar data acquisition (RDA) module. The NWS will continue to improve the accuracy of the forecast models used by the FAA. New products, including the predictive locations for hazardous weather, are being introduced into NEXRAD, and improvements in AP removal algorithms continues.

The NWS will continue to upgrade current sensors, thereby enhancing and expanding the capability to automatically provide accurate observations. Lightning detection will be improved to include all forms of lightning, not just the current cloud-to-ground strikes. Aircraft functioning as sensors of weather data will become a key element in improving the accuracy of weather forecast models and will validate new algorithms.

The NAS-wide information service will enable the FBWTG to interface more effectively with the NAS. Weather satellite data will also be available via the FBWTG.

Processing and Display

The ITWS will undergo a technology refresh that incorporates weather satellite data and implements algorithms for vertical windshear, storm growth and decay, icing aloft in the terminal area, in-flight icing, and runway visual range (RVR)/visibility and ceiling predictions. The goal is to expand ITWS predictive capability beyond 30 minutes (to several hours). The modular design allows ITWS enhancements to be used at more terminals. Some ITWS algorithms could be used at second-level airports running on a local processor or an ITWS variant. ITWS data will be displayed to controllers on the Standard Terminal Automation Replacement System (STARS) workstations in TRACONs and towers as part of the STARS preplanned product improvement (P^3I). ATCSCC traffic managers will receive ITWS data, enabling them to track storm activity at major airports and to facilitate coordination with TRACONs and major hubs.

Weather-in-the-cockpit products transmitted via FIS in this time frame may include improved weather radar information, hazardous weather advisories, observations and forecasts, winds and temperatures aloft, gridded forecast data, and pilot reports (PIREPs). These data are tailored to provide a "high-glance" value display of significant weather along the flight path. Different types of users can still expect varied levels of support; full graphical display of high-resolution data in the cockpit is the ultimate goal.

New algorithms will transition to the NWS for incorporation into their forecast models. A new icing forecast technique is scheduled to be incorporated into AWC's SIGMET and icing forecasts. Additionally, the NAS will receive finer resolution data from the NWS, thereby improving ITWS and CTAS pFAST products.

As the NAS-wide information service is deployed and as new methods of distributing weather data develop, WARP will transition away from its role as an en route weather server within the ARTCC. WARP and ITWS will remain collectors and processors of data, but will require less direct interfaces to user systems with the implementation of the information exchange service. Data will reside on distributed data bases, so it will not always be necessary to directly interface with ITWS or WARP—only with the information exchange network.

26.1.4 Weather Architecture Evolution—Step 4 (2009–2015)

ITWS and WARP will continue to produce new and improved weather products to support other NAS systems (see Figure 26-4). As the demand for products continues to grow and become more complex, these systems will evolve. In addition, the WARP hardware will be replaced and new algorithms will be added, increasing its capabilities. As the NAS-wide information service matures, it will incorporate the WMSCR functionality.

Weather-in-the-cockpit will be improved as new products are able to be transmitted via the FIS data link. These products include freezing level, wake turbulence, ceiling/visibility, and volcanic ash cloud forecasts. The addition of the gridded products from ITWS and WARP will require higher bandwidth data link and advanced avionics

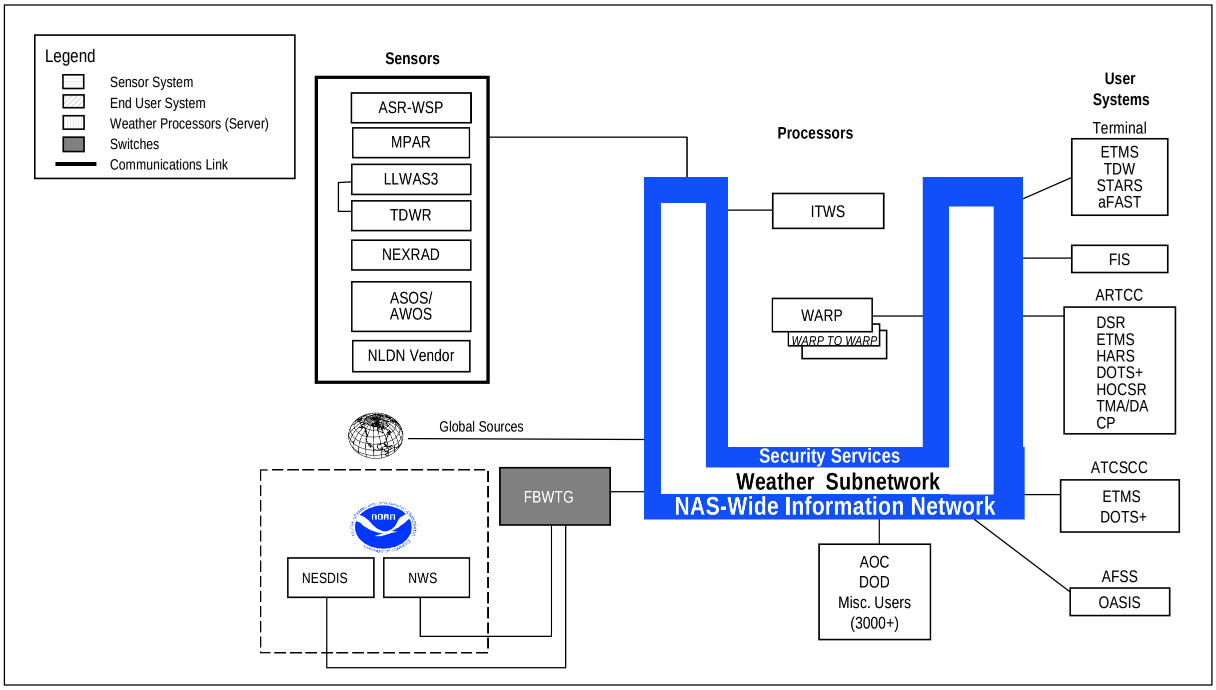

Figure 26-4. Weather Architecture Evolution—Step 4 (2009–2015)

to fully exploit the available information. The flight plan will become a flight object, and the system will automatically inform the pilot via FIS of any significant or hazardous weather. FIS data link and avionics will be more capable and cost-effective during this time frame.

The FAA will continue to use the AWR Program and leverage its affiliation with research agencies to improve the safety and capacity of the NAS by improving algorithms within existing systems. Results from the FAA's wake vortex research program will be implemented, thereby increasing the understanding of vortex behavior, leading to possible reduction of separation standards (see Section 10, Research, Engineering, and Development). Additionally, these algorithms will be ported to processors/systems at airports where it is cost-effective.

Sensors and Data Sources

The next generation of airport surveillance radar will detect both aircraft and windshear events. A multipurpose airport radar (MPAR) will be deployed late in Step 4 that will replace ASR-9s and -11s, LLWASs, and TDWRs. MPAR provides improved maintainability and reliability while reducing spectrum demand and environmental impacts. (see Section 16, Surveillance).

Processing and Display

The NAS-wide information service enables more efficient data searches and queries for all NAS users for any type of data to improve the collaborative decisionmaking process. This information exchange network allows all NAS users to be updated simultaneously, in near real-time when hazardous weather occurs and ensures that all weather products are maintained in a common data base. FIS capability will be improved to transmit enhanced data to the cockpit for display of significant weather. ITWS will receive a technology refresh, allowing it to support multiple terminal sensor configurations.

In the cockpit, the pilots see the same data as other NAS users and can query the weather data base to obtain additional information.

26.2 Summary of Capabilities

The NAS weather architecture will undergo evolutionary changes over the next 5 to 10 years, enhancing its capability to collect numerous types of weather data from internal as well as external sources, then process and disseminate tailored weather products to both NAS users and providers. Figure 26-5 depicts these enhanced capabilities chronologically. In 1997, the first stage of WARP was implemented nationally. CWSU me-

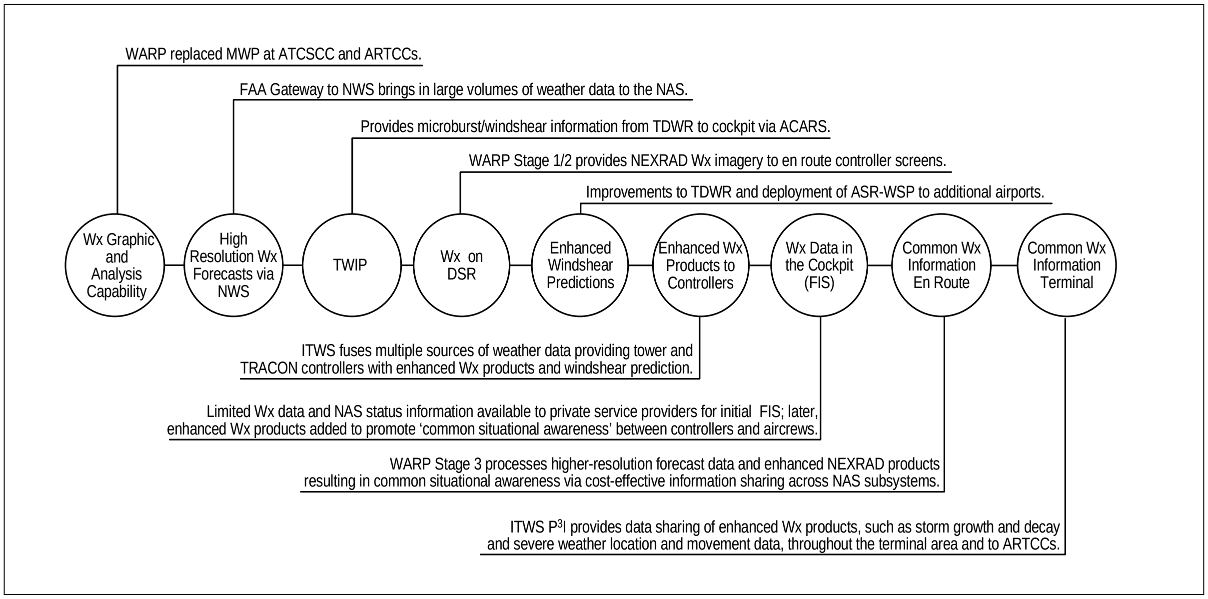

Figure 26-5. Aviation Weather Capabilities Summary

teorologists now have upgraded graphical display and analytical capabilities and can provide better weather support to controllers and traffic flow managers in the ATCSCC and the ARTCCs.

Almost immediately, the NAS will receive high-resolution forecasts of weather data from the NWS. Implementing the high-speed communications link (i.e., FBWTG) between the NWS and the FAA will provide high-definition, high-quality, gridded weather products to the NAS. These high-resolution data sets contain more accurate forecasts of weather information, such as winds and temperature and of aviation-impact variables such as in-flight icing. This enables controllers and traffic managers to plan for aviation-impacting weather.

TWIP currently provides microburst and windshear information from TDWR to commercial aircraft cockpits via ACARS. With the addition of ASR-WSP sites, TWIP coverage will be expanded.

As part of the FAA's FIS policy, the FAA will provide NAS status and existing weather data (including some WARP and ITWS products) to a commercial service provider for data link to the cockpit.

About the same time, en route controllers will see weather from NEXRAD overlaid on their displays as WARP Stages 1 and 2 interface with the DSR. This will help controllers assist aircrews in avoiding hazardous weather. It also eliminates the need for weather data from long-range radar, which allows selected sites to be decommissioned. Traffic managers will use weather information from their WARP briefing terminals for contingency planning. In support of FFP1 CCLD, WARP accelerates Stage 3 interfaces to prototype URET CCLD, ETMS, and CTAS TMA/pFAST sites to provide higher-resolution wind and temperature data.

Early in the modernization process, NEXRAD will be completely converted to an open system architecture, increasing its product generation and dissemination capabilities to fully exploit the radar data. ITWS and WARP will receive improved radar products.

ITWS deployment will be completed shortly thereafter, vastly improving the FAA's ability to monitor atmospheric phenomena in the terminal domain. ITWS provides accurate forecasts of wind shifts associated with frontal passage, thereby mitigating their effect on capacity. ITWS also enhances safety with its windshear prediction capability.

WARP will be connected to other users, completing Stage 3 implementation. This permits tailored products to be shared by NAS users and service providers. Additional algorithms will enhance

NWS forecast data and improve NEXRAD radar products.

ITWS will incorporate new algorithms, enhancing its capability to forecast events such as storm growth and decay, ceiling and visibility, RVR, runway winds, and turbulence.

26.3 Human Factors

The primary focus of human factors related to aviation weather is the efficient and effective presentation of weather products to the meteorologist, dispatcher, controller, and pilot. Of key importance will be determining the informational requirements at various locations and recognizing the possibility that these needs may be different for different classes of aircraft and different service provider locations. To assist aircraft most effectively, controllers will need to know the precise location of an aircraft and which weather products are available to the pilots.

Future systems will move away from separate controls and displays for individual subsystems, therefore, human factors efforts must focus on developing integrated displays and controls, in which weather products are one element of a larger presentation. Human factors will be a major factor in designing integrated workstations. The information needed by controllers must be presented in a timely manner so that workload is maintained within acceptable limits.

Lastly, as the FAA moves toward Free Flight, more information will be needed by the pilot and the controller, particularly for GA aircraft operations. Appropriate training will need to be developed to ensure that pilots and service providers can effectively use the weather information that is presented.

26.4 Transition

The transition schedule for the major components of the aviation weather system is shown in Figure 26-6. The principal transitions include:

- FBWTG Phase 1 deployed
- WARP Stages 1 and 2 deployed (NEXRAD on DSR)
- NEXRAD open system upgrade to RPG
- ITWS deployed
- ASR-WSP deployed
- NEXRAD open system upgrade to RDA
- Satellite data via FBWTG Phase 2
- ITWS products on STARS displays

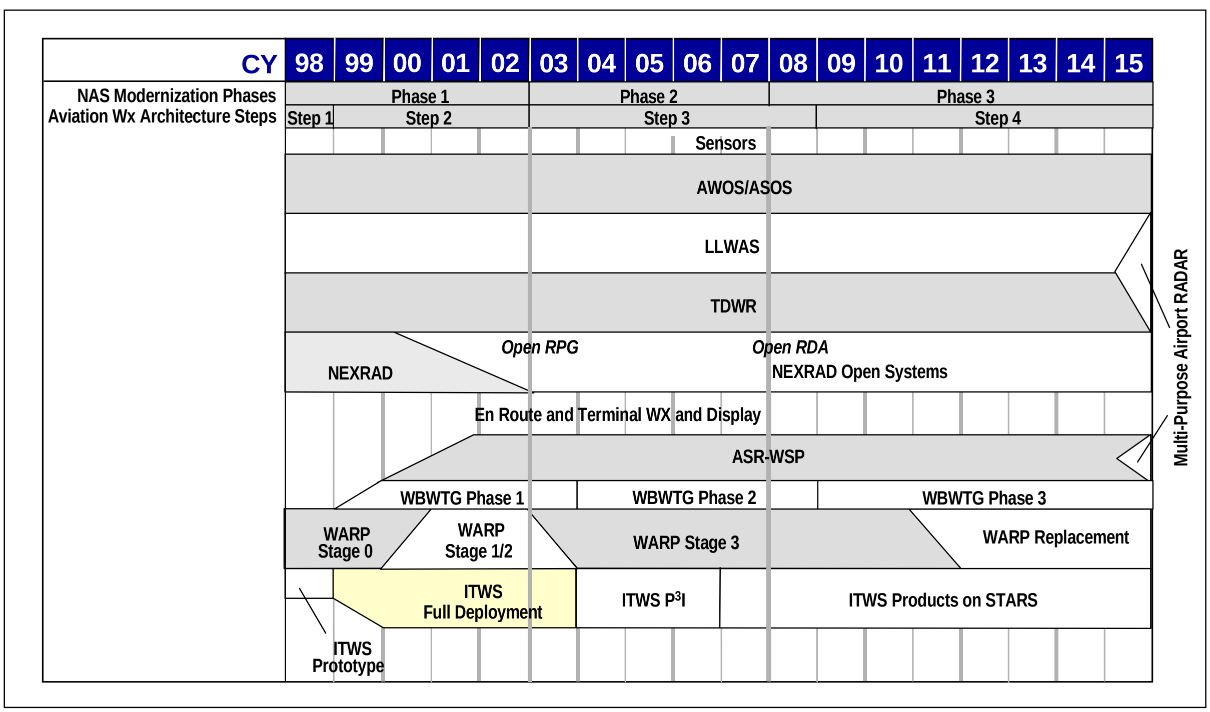

Figure 26-6. Weather Systems Transition

- FBWTG Phase 3 upgrades for NAS-wide information service compatibility
- Consolidated terminal and weather radar deployed (MPAR) (see Section 16, Surveillance).

26.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for aviation weather architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 26-7.

26.6 Watch Items

Several items are critical to the aviation weather architecture. These include adequate radio frequency spectrum for ASOS and AWOS, tri-agency funding for NEXRAD upgrades, and implementation of private service provider FIS.

- Without adequate radio frequency spectrum for ASOS and AWOS, pilots cannot receive surface weather observations for new ASOS and AWOS locations.
- Tri-agency (FAA, DOD, and NWS) ability to fund and implement NEXRAD system upgrades in a timely manner, enabling WARP, ITWS, and OASIS to receive FAA-specific products.
- FIS implementation dependent upon available frequency spectrum and commercial service provider participation.

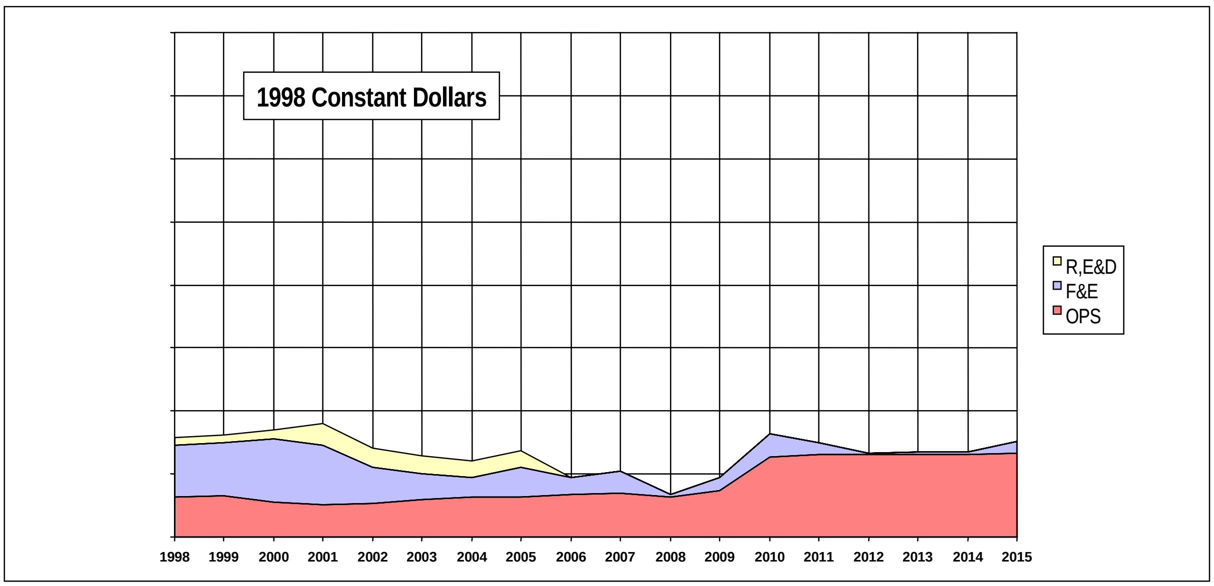

Figure 26-7. Estimated Weather Systems Costs

PART III

27 INFRASTRUCTURE MANAGEMENT

Today's NAS infrastructure includes more than 30,000 air traffic control (ATC) systems. These infrastructure systems, which continue to increase in number faster than the Airway Facilities (AF) workforce that maintains them, include communication, surveillance, navigation and landing, weather sensors, and air traffic automation decision support systems (DSSs). NAS infrastructure systems support the air traffic operations carried out at air traffic control towers (ATCTs), terminal radar approach control (TRACON) facilities, air route traffic control centers (ARTCCs), airports, and other facilities. It is imperative that the performance of these systems be maintained to preserve the integrity of the NAS infrastructure and thereby avoid delays or disruptions in air traffic.

AF's greatest strength is the technical expertise of its workforce, its dedication to excellence, and the resulting level of public trust. The NAS infrastructure management (NIM) philosophy—which stresses decisionmaking alliances composed of AF elements and the AF customer base—has been initiated. AF operations business will be based on the NIM philosophy.

This philosophy embodies a strong customer orientation with an emphasis on cost-effectiveness and efficient and effective delivery of air traffic services. This concept, described in the *Airway Facilities Concept of Operations for the Future*, March 1995, represents a fundamental shift in the FAA's focus from the decentralized equipment maintenance performed today to centralized *service* management. The concept responds to anticipated changes in the NAS environment by promoting:

- Partnerships with organizations, both within and external to the FAA, to promote customer and stakeholder inclusion in setting strategic and tactical directions
- A strong customer orientation to ensure that AF is doing the right things, in a timely manner, to meet end-to-end customer service delivery needs
- A flexible, integrated information infrastructure to support the anticipation, identification, decisionmaking, and resolution of problems before service quality is affected
- A more expert workforce to exploit the full potential of emerging technologies and work "smarter" in meeting increased customer needs while maintaining workforce resources
- An emphasis on cost-effectiveness through a more businesslike approach to costs, measured performance, and focused resources.

A NIM capability combining technology, organizational changes, and reengineered processes will support the real-time information exchange essential to progress toward FAA/industry collaborative decisionmaking and the economics of implementing such concepts as Free Flight. NIM supports free flight through improved NAS service availability.

Implementing the infrastructure management philosophy will enable the FAA to provide more efficient and effective management of a growing NAS, reduce the NAS mean time to restore, and increase the productivity of the AF workforce, thereby improving air traffic services.

NIM implementation tools will be based on proven state-of-the-art systems management concepts in which functions are distributed among the central management servers, agents, and the managed resources themselves. NIM tools will use industry-standard computing platforms, information structures, and communication interfaces. The system technology will include commercial off-the-shelf (COTS) client/server platforms and applications that support industry standard management interfaces with open application program interfaces, standard data base technology, and interfaces for data sharing with other DSSs.

NIM tools build upon the remote maintenance monitoring system (RMMS) by leveraging existing assets and providing new automated management capabilities. Through NIM tools, the FAA will be able to remotely detect system faults and remotely resolve many faults. Collecting and analyzing more detailed fault and performance data will support proactive management of the NAS infrastructure. NIM capabilities will include remote monitoring and control; NAS modeling; and event, fault, maintenance, performance, resource, voice and data communications, and security management. The combination of new technology, organizational changes, and reengineered processes will enable the FAA to contain infrastructure maintenance costs while ensuring a consistently high level of service.

27.1 Infrastructure Management Architecture Evolution

The NIM phased implementation approach is based on the managed evolutionary development (MED) concept, which requires demonstrated performance before progressing to the next phase. Actual infrastructure management will be accomplished in four steps.

Step 1. Step 1 involved enhancing the RMMS by establishing remote monitor and control capabilities to nearly 4,000 remote NAS facilities. Initial stages of integration included development of a prototype NIM, which provided for a concept evaluation and investigated future development capabilities.

Step 2 (NIM Phase 1). During Step 2, an initial NIM capability will be incrementally deployed. Selected system service components (SSCs) (i.e., the National Operations Control Center (NOCC), operations control centers (OCCs), service operations centers (SOCs), national network control centers (NNCCs), work centers (WCs), and mobile system specialists capabilities) will be established during this time frame.

At the beginning of this step, NIM capabilities will be installed at four of the NIM SSCs, the NOCC, and the three OCCs. Prior to the beginning of final operational capability (FOC), resource management capabilities will be installed at all NIM SSCs. At this point, NIM will include new COTS-based resource management capabilities and legacy RMMS-based enterprise management capabilities. Full NIM resource and enterprise management capabilities will be operational at all SSCs by FOC.

Step 3 (NIM Phase 2). During Step 3, capabilities will be expanded and refined.

Step 4 (NIM Phase 3). Advanced NIM capabilities will be implemented, including intelligent fault correlation, reliability-centered maintenance, predictive maintenance, and NAS-wide information sharing.

27.1.1 Infrastructure Management Architecture Evolution—Step 1 (1996–1997)

The initial step in the evolution of infrastructure management consisted primarily of organizational changes, including consolidating management and maintenance facilities and acquiring and fielding advanced maintenance tools for operations support specialists. The RMMS is the primary automation system supporting NAS infrastructure operations during this step (see Figure 27-1). An integral part of the RMMS is the maintenance control center (MCC). AF's Maintenance Automation 2000 MCC operations concept focused on centralizing the management of maintenance operations for facilities at the sector level. These decentralized sectors operate and maintain equipment and facilities within their domain of responsibility based on local requirements and priorities. The MCC uses automation tools in a limited capacity to assess equipment performance, obtain real-time facility status information, perform remote facility certifications, and dispatch personnel as needed to accomplish facility/service restoration.

The heart of the RMMS network consists of 22 maintenance processor subsystems (MPSs) located within the ARTCCs. An additional MPS is located at the NIM premier facility (NPF) in Herndon, Va., which is co-located with the National Maintenance Control Center (NMCC), part of the ATC System Command Center. Using two resident software applications—the maintenance management system (MMS) and the interim monitoring and control system (IMCS)—maintenance personnel located in the MCCs remotely monitor the status of selected NAS subsystems, log maintenance actions, and report service and facility interruptions and equipment failures. The MPS also schedules preventive system maintenance actions and enables remote certification of facilities and equipment. Each MPS is capable of supporting up to four MCCs. The MPSs interface with NAS subsystems through a monitoring system function, which is either embedded or external to those subsystems. Some NAS subsystems provide their own monitoring/management and are known as element management systems.

Maintenance specialists at MCCs and at more than 300 work centers throughout the United

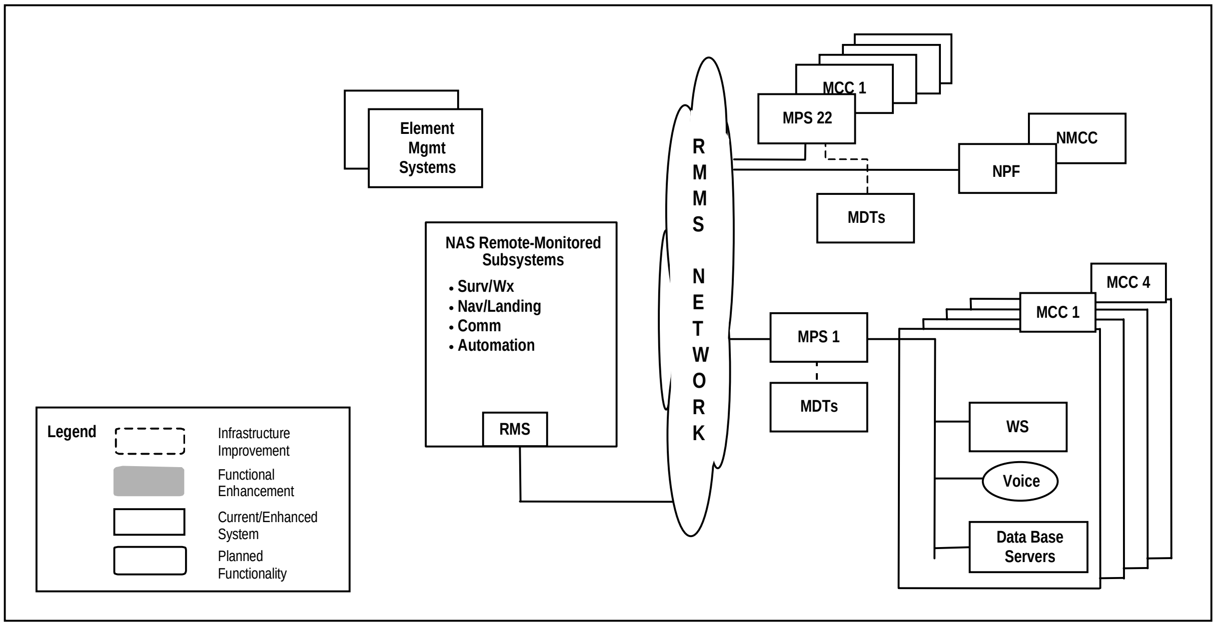

Figure 27-1. Infrastructure Management Architecture Evolution—Step 1 (1996–1997)

States have the primary responsibility for maintaining the NAS subsystems. Additionally, many remote facilities have permanent, onsite maintenance operations personnel due to their critical role in providing NAS services.

During Step 1, selected MCCs established prototype facilities for NIM concept evaluation and development capabilities.

27.1.2 Infrastructure Management Architecture Evolution—Step 2 (1998–2002)

The major activity at the beginning of Step 2, which is Phase 1 of the NIM implementation, was the opening of the NPF in June 1998. The NPF is used for demonstrations, training, and the development of new business processes, policies, and procedures. Initially, the NPF has demonstrated Build 1 and Build 2 of the NIM capabilities and will be able to continue the development of new business processes, policies, and procedures. In this step, the NPF will demonstrate the NIM Phase 1 initial operational capabilities that will be used at the NOCC, NNCCs, OCCs, SOCs, and WCs and by the mobile specialists. The major emphasis of NIM is on resource management. During this time frame, monitoring and control functions in the NPF will use the legacy system capabilities—the RMMS and element management systems.

The infrastructure management architecture for Step 2 (see Figure 27-2) is based on a three-tiered operations concept in which communications between tiers is provided via a local services network. NIM will consist of nodes located at one NOCC, two national network control centers (NNCCs), three OCCs, about 50 SOCs, and more than 300 WCs. The NOCC and OCCs will be responsible for centralized management of the NAS infrastructure.

NOCC. The NOCC is the operations control center that monitors the delivery of NAS infrastructure services to users and customers from a national perspective. It provides 24-hours-a-day, 7-days-a-week monitoring of infrastructure status and event response via OCC-reported information. The NOCC reports significant NAS infrastructure events to senior FAA management and coordinates transmittal of information to customers concerning events that could affect them. It monitors and assesses activities aimed at restoring services that have a critical affect on customers. Trend analysis such as the health of the NAS and NAS operational financial data will be available for FAA management analysis and reporting purposes at the NOCC.

OCCs. The primary role of each OCC is to manage the NAS infrastructure within its domain of responsibility. It directs the maintenance of NAS

PART III

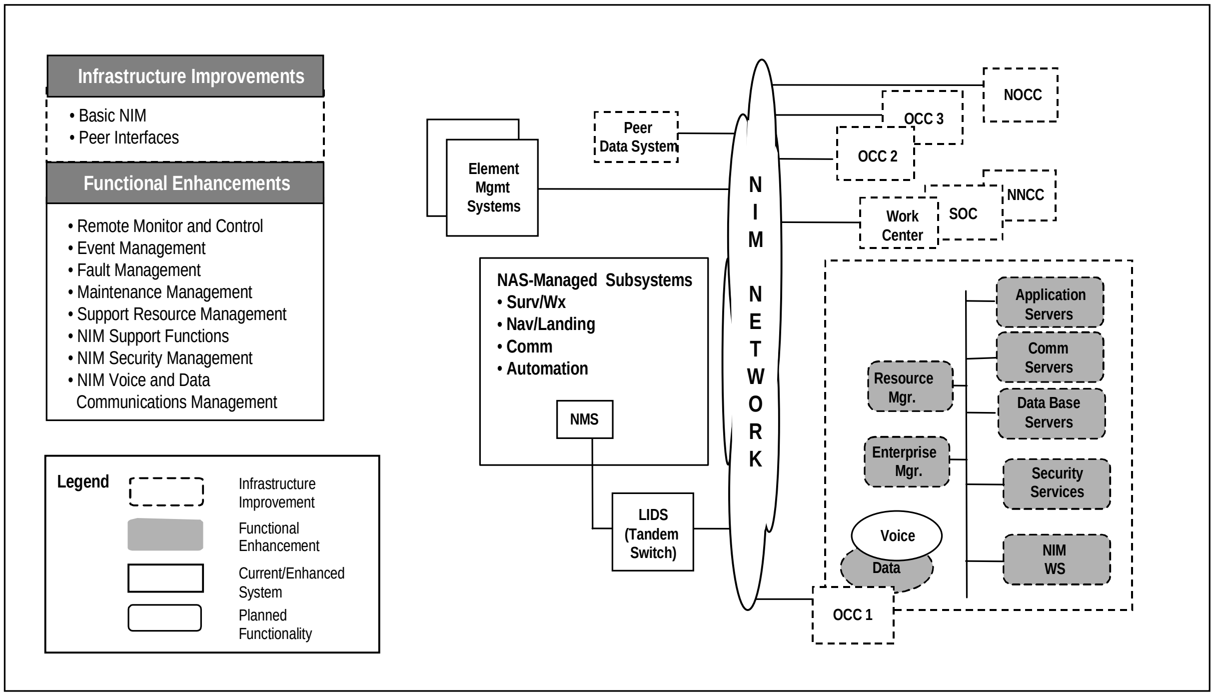

Figure 27-2. Infrastructure Management Architecture Evolution—Step 2 (1998–2002)

services and systems, providing active response and problem resolution. To accomplish this, each OCC operates 24-hours a day, 7 days a week, responding to faults and continuously monitoring the delivery of services and the status of the systems and equipment supporting those services. OCCs exercise operational control of their assigned domains of responsibility and oversee multiple work centers. Each OCC will be capable of assuming the responsibility of any other OCC that fails or is unable to provide services.

WC/SOC. The primary role of the WC is to maintain designated airways facilities. Each work center supervises its assigned workforce, ensures response to tasking, and is responsible for the equipment in specific geographic areas. SOCs are WCs that provide an AF presence at a high-impact facility when it has been determined that onsite coverage is necessary for efficient and effective delivery of service either to the facility or within a limited geographic area surrounding the facility. High-impact facilities include NNCCs, ARTCCs, large TRACONs, and ATCTs with significantly high numbers of operations. Operations support specialists will be provided with updated desktop and portable maintenance data terminals (MDTs). Cellular and satellite telephones and pagers will be used to supplement existing communications systems.

NNCCs. The primary role of the NNCCs is to monitor and control selected nationwide area telecommunications networks and to interface with the NOCC, OCCs, SOCs, and leased service providers to provide real-time operational status information. In addition, the NNCCs will interface with the appropriate OCCs for workforce and resource assignments during any planned or unplanned outages of NNCC-managed elements.

During Step 2, the MPS will transition to the Tandem switch, which is part of the legacy information distribution system (LIDS). RMMS functionality will be absorbed by the NIM resource manager located at the OCCs. Initially, IMCS functionality will transition to the maintenance automation system software (MASS) monitor and control function, which will reside in LIDS. By the end of Step 2, a COTS enterprise manager will be introduced. The interim and final enterprise managers will be capable of performing in an open operating system environment. The existing RMMS will be enhanced with an open system capability through LIDS. NIM tools and the enhanced RMMS will be collectively identified as NAS managed subsystems (NMSs). At the end of

Step 2, more than 6,000 NMSs will be automatically interfaced with the enterprise manager.

During Step 2, information from the logistics inventory system (LIS), corporate information management system (CIMS), regional information system (REGIS), and notice to airmen (NOTAM) will be available for NIM.

Basic functional capabilities included in Step 2 include:

- *NAS Modeling*: Define relationships between NAS elements, associate a criticality level to each resource, and provide tools to maintain a data base of the relationships
- *Remote Monitor and Control:* Remotely collect and process status information from NAS infrastructure resources, define authorized users, and establish access control to the commands
- *Event Management:* Classify and type events, and track NAS maintenance activities
- *Fault Management:* Generate alarms and alerts and manage actions to resolve the events that caused the alarms
- *Maintenance Management:* Match available maintenance resources with tasks that need to be completed
- *Support Resource Management:* Maintain information on the status of all resources required to support the NAS
- *NIM Support Functions:* Log, archive, and analyze NIM tool operational data
- *Security Management:* Protect NIM tool data via user identification, authentication, and access control mechanisms; support NAS-wide security management, such as detecting and logging NAS infrastructure security violations for reporting to FAA management
- *Manage NIM Voice and Data Communications:* Ensure appropriate communications capabilities at each user position.

27.1.3 Infrastructure Management Architecture Evolution—Step 3 (2003–2005)

Step 3 of the evolution, which is Phase 2 of the NIM implementation (see Figure 27-3), capitalizes and improves on the Phase 1 investment through the application of managed evolutionary development (MED). It will integrate existing element management systems, monitor environ-

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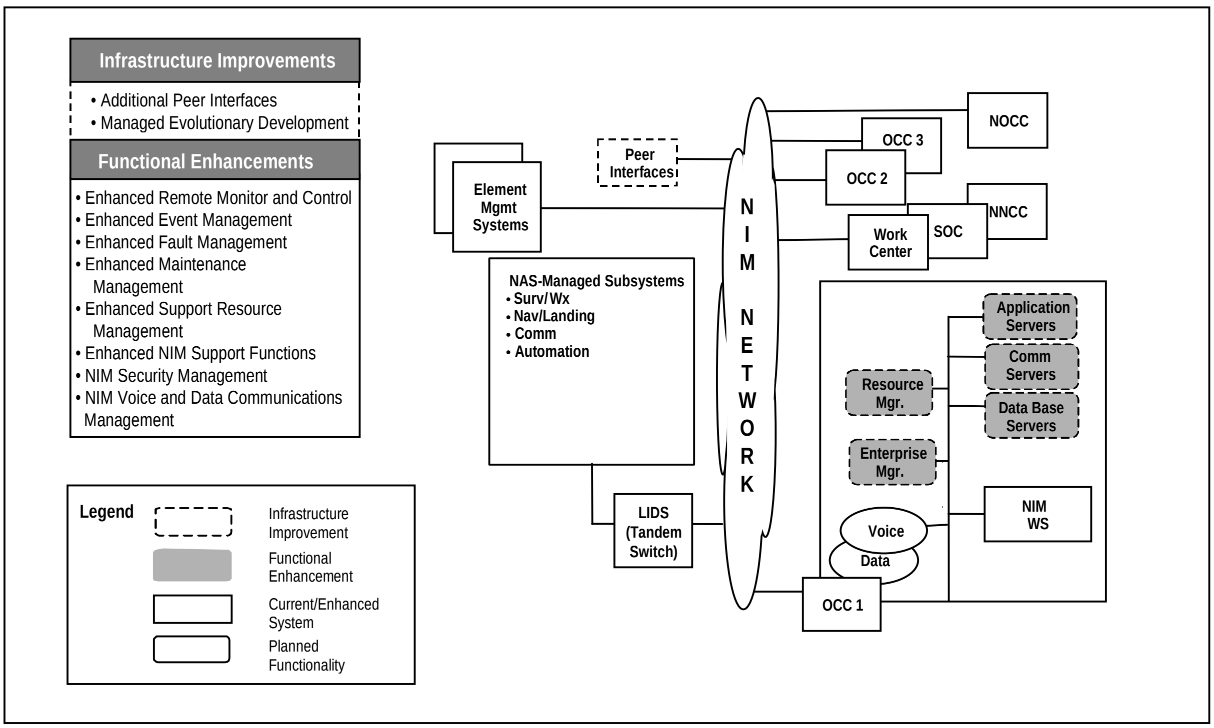

Figure 27-3. Infrastructure Management Architecture Evolution—Step 3 (2003–2005)

mental systems, and expand local information exchange services within the NAS.

The synergistic effect of integrating all resource management functions and the enterprise management function will result in seamless service management. Service management will improve services and reduce associated costs from both an individual or component service perspective and a multiservice perspective. The sum of multiple services forms the end-to-end service delivered to AF customers.

27.1.4 Infrastructure Management Architecture Evolution—Step 4 (2006–2015)

Step 4 of the evolution, which is Phase 3 of the NIM implementation (see Figure 27-4), will refine the capabilities provided in Steps 2 and 3 through continued application of MED. It will also initiate intelligent fault correlation, reliability-centered maintenance, predictive maintenance, enhanced information sharing with NIM tool internal and external users, and continued connection of new and legacy systems.

27.2 Summary of Capabilities

NAS infrastructure management development, through the process of MED, is leveraging the FAA's investment in the RMMS into a performance-based management system, which is focused on managing the NAS infrastructure so customer services are based on established performance standards, customer expectations, and business objectives. Following establishment of an initial RMMS capability in Step 1, each subsequent step in the evolution builds on the procurement of proven COTS products. Step 2 builds on the existing RMMS and establishes the three-tiered operations concept by:

- Establishing NOCC, OCC, and SOC/WCs
- Establishing a modern information infrastructure featuring resource and enterprise management, including security
- Establishing external interfaces with selected peer systems
- Increasing the number of remotely monitored and controlled NAS facilities
- Replacing technologically obsolete MDTs used by AF specialists
- Supplementing existing fixed communications capabilities with mobile communications equipment and services for AF specialists.

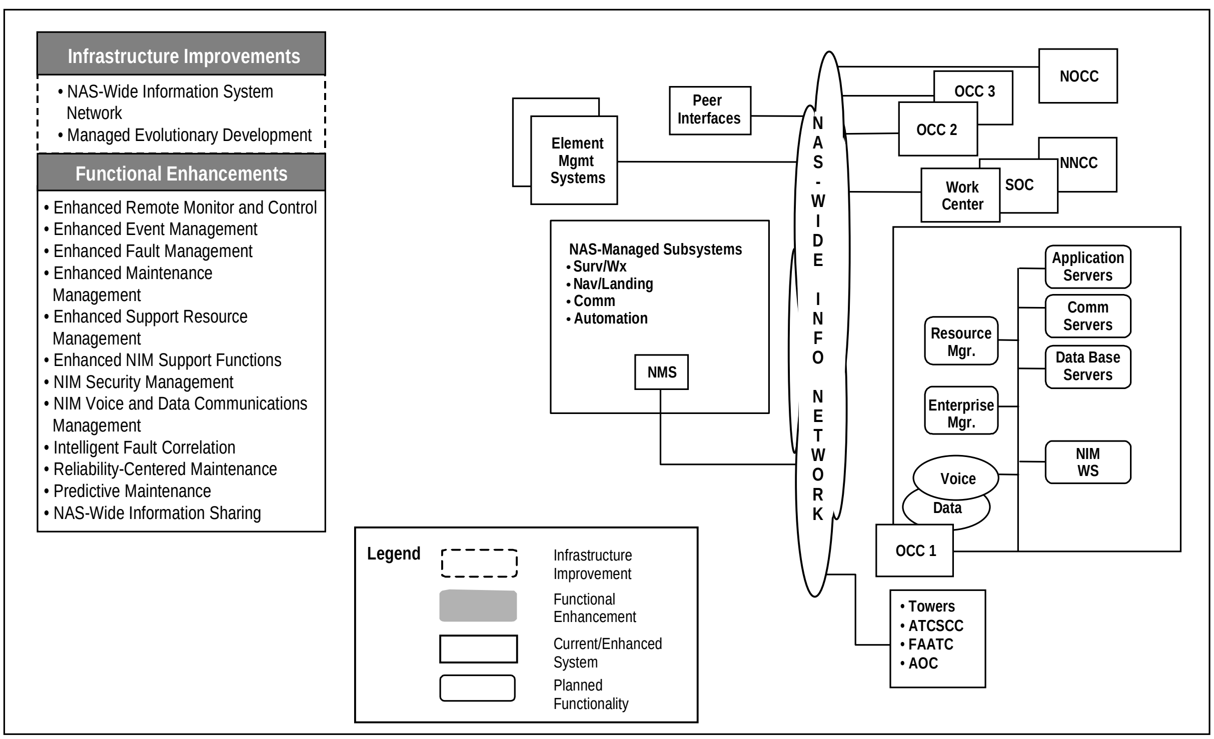

Figure 27-4. Infrastructure Management Architecture Evolution—Step 4 (2006–2015)

Step 3 continues the modernization and refinement of Step 2 capabilities while Step 4 initiates intelligent fault correlation (i.e., reliability-centered maintenance and predictive maintenance as well as enhanced information sharing). Step 4 also continues life-cycle modernization and refinement of NIM capabilities. As emerging technologies mature and become readily available, NIM will incorporate new functional capabilities yet to be identified throughout this final phase of its life cycle.

27.3 Human Factors

Human factors planning for NIM tools involve defining a process for incorporating human factors engineering into the development, acquisition, implementation, and operation of the control and work centers that comprise NIM, as well as for its associated equipment, capabilities, facilities, and personnel. For many years, the number of subsystem-specific interfaces technicians use in maintaining the NAS has steadily increased. These interfaces include diverse displays, keyboards, and controls with different computer-human interface (CHI) characteristics. NIM tools will incorporate a human-centered workstation design to enhance efficiency and effectiveness. The goal of NIM tool human factors engineering is to make the most effective use of human capabilities and to minimize the effects of human limitations and errors on the performance of the system.

The NIM will center on adapting and integrating components and subsystems that are developed using fast-track methods, including acquisition of COTS/nondevelopmental item (NDI) hardware and software products. The application of human factors criteria to subsystem selection will provide systems that better support users. As subsystem capabilities are developed, a subsystem's operational suitability will be determined through operational test and evaluation. The subsystem will be systematically assessed in terms of human factors requirements, criteria, measures, and procedures.

Because training provides people with needed knowledge and skills, it directly affects system performance and is a critical human factors issue that will be considered in detail. The training program must reduce training time through more efficient training methods and impart a wider scope of technical knowledge and skills to a reduced workforce. Because training can be very costly over a system's service life, and its delivery affects the availability of personnel for conducting operational tasks, it is considered to be an integral part of the system engineering design process. Traditional training will be augmented with other job performance aids.

NAS personnel requirements are determined by system equipment design, procedures, training, NAS workload, and other factors. Human resource tradeoff studies will be conducted to examine staffing requirements in relation to system productivity.

27.4 Transition

The schedule for the NIM implementation is shown in Figure 27-5. This schedule will be revised after requirements are stabilized.

27.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for the infrastructure management architecture in constant FY98 dollars for 1998 through 2015 are shown in Figure 27-6.

27.6 Watch Items

Enforcement of FAA Order 6000.30. With the onset of user-intensive concepts such as Free Flight, maintaining the integrity of the NAS infrastructure while using such advanced technologies as NIM tools takes on added importance. However, liberal interpretation of FAA Order 6000.30 (Policy for Maintenance of the NAS Through the Year 2000) has resulted in many instances of noncompliance with the intended maintenance policy, thereby negating the benefits to be gained from NAS-wide implementation of an infrastructure management system. More stringent adherence to the AF CONOPS, with added emphasis on improving the integrity of the NAS infrastructure and the resulting benefits to the user community, is imperative.

Agreement on NIM Requirements. More work is needed to define requirements and operational procedures for using remote, automated control of NAS assets. Operational concepts need to be de-

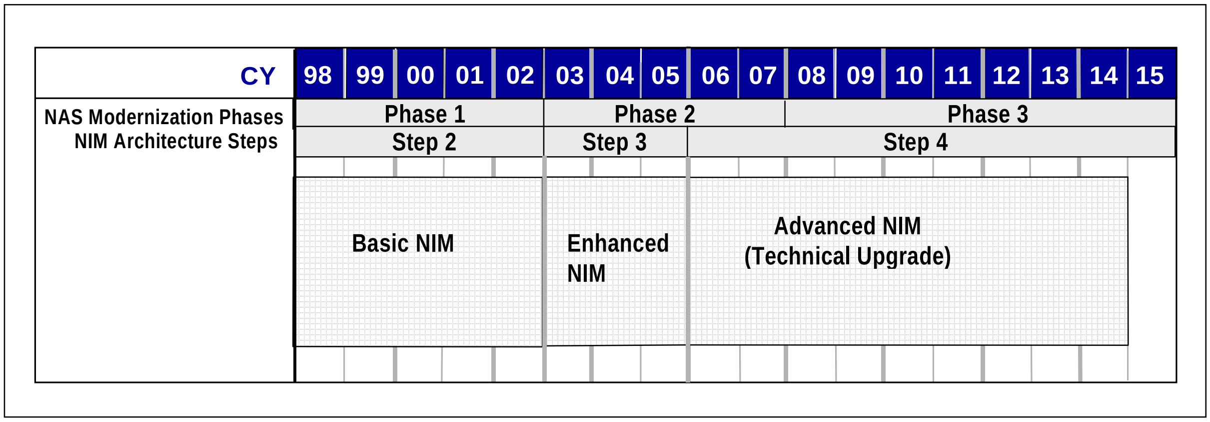

Figure 27-5. Infrastructure Management Transition

fined and modeled to assess workload improvements.

Implementation of NAS-Wide Security. NIM tools interface with all other NAS systems, and access to it must be restricted. For this reason, management and control of NAS security services is included in the NIM architecture. Within NIM tools, INFOSEC requirements are based on the NIM protection profile and vulnerability assessment. Adequate security is ensured for NIM tools by meeting requirements for service availability, access control, authentication, nonrepudiation, confidentiality, and integrity. In particular, appropriate security gateway services are available to provide proper access control between NIM tools and the NAS-wide information network. This reinforces consideration of NIM tools when it comes to planning for collection of NAS-wide subsystem security data for reporting and auditing purposes and to perform NAS-wide intrusion detection and key management.

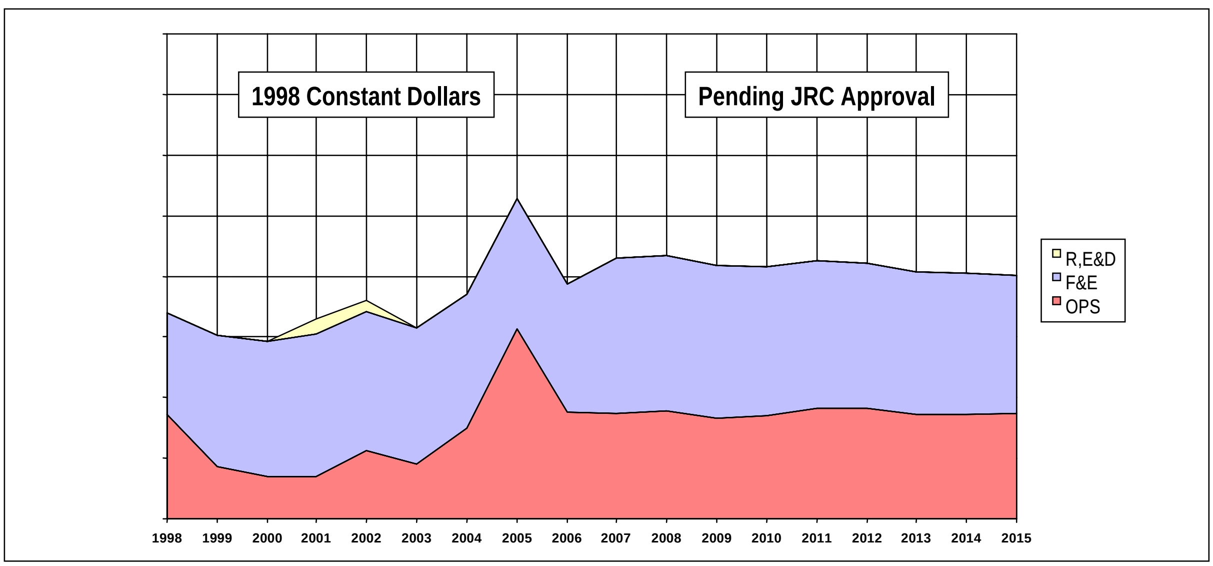

Figure 27-6. Estimated Infrastructure Management Costs

28 AIRPORTS

The airport is a key component of the NAS, and this section addresses the architecture from an airport operator's viewpoint, focusing on aircraft movement from gate to gate and chock to chock through the system. This section summarizes the services, operational concepts, and capabilities associated with surface movement, landing, and departures.

28.1 Airport Operations

Airport operators are involved with many aspects of system performance, including safety, capacity, environmental compatibility, and financial performance. These may be affected by various factors, including the layout of individual airports, the manner in which airspace is organized and used, operating procedures, and the application of technology.

The primary goal is to maintain the high level of safety. This involves providing pilots with information in a convenient and useful manner, maintaining airport facilities to high standards, and providing a safe and secure aircraft operating area.

Runway capacity to accommodate the anticipated number of aircraft operations is a concern at major metropolitan airports where passenger and cargo traffic are concentrated. Inadequate runway capacity results in air traffic delays, additional expense for airlines, inconvenience for passengers, and an increased workload for the FAA air traffic control system. Experience shows that delay gradually increases as air traffic levels rise, until the practical capacity of an airport is reached, after which the average delay per aircraft operation is from 4 to 6 minutes. After this, delays increase rapidly.

An airport is considered to be severely congested when average delay exceeds 9 minutes per operation. Beyond this point, delays become volatile, and a small increase in traffic, adverse weather conditions, or other factors can result in lengthy delays that disrupt flight schedules and impose a heavy workload on the air traffic control system. Adverse weather has a substantial impact on airport capacity, especially at major hubs. The 1997 Aviation Capacity Enhancement Plan indicates that from 1992 through 1996, adverse weather was a major factor affecting NAS capacity, accounting for 72 percent of system delays greater than 15 minutes. Seven airports with an average delay in excess of 9 minutes per operation accounted for most of the severe air traffic delays in the United States in 1996.

The FAA estimates that, if demand were to increase as expected, no new runways were added to major airports, and no advances were made in air traffic control, 15 major airports would be severely congested by 2006. Capacity enhancements are expected as a result of planned new runway construction at certain airports and also from the improvements in air traffic control, such as the passive Final Approach Spacing Tool (pFAST), a new air traffic control (ATC) spacing and sequencing tool that promotes a more efficient flow of air traffic (see Section 23, Terminal). For example, the Dallas-Fort Worth Airport has successfully blended airport capacity planning and the use of pFAST to significantly increase the airport acceptance rate. The effects of these improvements will vary from airport to airport, and site-specific analyses are needed to provide a reliable estimate of the combined effect of all anticipated improvements. The FAA intends to undertake such analyses in partnership with airport operators and users to better understand the future balance between demand and capacity at major airports.

To mitigate the effects of adverse weather on airport capacity, the FAA is implementing a weather architecture in the near term, featuring systems that will be integrated into the overall NAS architecture. One of those systems, the integrated terminal weather system (ITWS) will provide dedicated, enhanced weather support to 45 of the nations's busiest airports. ITWS will receive a myriad of weather data from radars, ground-observing systems, airborne observations, and computer model output. ITWS will then process these data and provide tailored products, such as short-range forecasts of airport-impacting weather to aid traffic supervisors and controllers in optimizing runway usage during storm passage. See Section 26, Aviation Weather, for more details.

Environmental considerations are critical in optimizing airfield capacity. Noise concerns have been a major obstacle to new runway construction and have limited the use of existing runways at some airports. Future enhancements of runway capacity must be compatible with surrounding land uses. Engine emissions are also a concern. The FAA is currently investing in improvements and new technologies for the NAS that will ease ATC restrictions. There are positive environmental and economic benefits to be realized with the planned improvements in capabilities. The estimated savings in fuel used and the reduced emissions are considerable.

Airports are typically owned and operated by local government, and are supported by charges, taxes, and fees paid by airport users. Every effort is made to provide services in a cost-effective manner.

Airports have a complex interrelationship with other NAS components, and good communications among FAA, state, and local officials are essential for NAS modernization to enhance the performance of the airport system.

28.1.1 Surface Movement Guidance and Control Goals

Like the rest of the architecture, airport surface movement begins with goals and operational concepts. The All Weather Operations Panel of the International Civil Aviation Organization (ICAO) has established high-level goals that have become the basis for considering which capabilities are required and may be useful in developing improvements for surface movement operations.[1] The following subset of those goals are applicable to the NAS architecture:

- Pilots, controllers, and vehicle operators should continue to have clearly defined roles and responsibilities that eliminate procedural ambiguities—which may lead to operational errors and deviations.
- Improved means of providing situational awareness should be developed for pilots, controllers, and vehicle operators, considering visibility conditions, traffic density, and airport complexity.
- Improved means of surveillance should be in place (beyond primary radar).
- Delays in ground movements should be reduced, and growth in operations should be accommodated without increases in delays on the ground.
- Surface movement functions should be able to accommodate all aircraft classes and necessary ground vehicles.
- Improved guidance and procedures should be in place to allow:
  - Safe operations on the airport surface, considering visibility conditions, traffic density, and airport layout
  - Pilots and vehicle operators to follow their assigned routes in a continuous, unambiguous, and reliable way.
- Airport visual aids that provide guidance for surface movement should be integrated with the surface movement system.
- Air traffic management automation should provide linkages between surface and terminal to produce a seamless, time-based operation with reduced controller and pilot workload.
- Surface movement guidance and control improvements should be developed in a modular form and accommodate all airport types.
- Conflict prediction/detection, analysis, and resolution should be provided.

28.1.2 Surface Operations Characteristics

In addition to the broad goals of ICAO, the Air Traffic Services (ATS) concept of operations (CONOPS) also covers characteristics for surface movement operations and services.[2] The following operating characteristics are consistent with the architecture:

- Improve information exchange and coordination activities, including the expansion of data link capabilities, to more users at more airports.

1. *All Weather Operations Panel Working Paper (AWOP/WP756)*, Sixteenth Meeting, Montreal, June 23 to July 4, 1997.
2. *A Concept of Operations for the National Airspace System in 2005, Air Traffic Services*, September 1997.

- Use automation to enhance the dynamic planning of surface movement, balance taxiway demand, and improve the sequencing of aircraft to the departure threshold.
- Integrate surface and terminal automation so that the most appropriate runway and taxi route can be utilized for the assigned gate. Current and projected areas of congestion on the surface, runway loading, and environmental aspects such as noise balancing will be considered.
- Share information between users and service providers to create a more realistic picture of airport departure and arrival demand.
- Use automation to improve the identification and predicted movement of all aircraft and vehicles on the airport movement area and provide conflict advisories.
- Enhance safety and efficiency by planning an aircraft's movement so that a flight can proceed from deicing to takeoff without stopping.

Airport surface movement guidance and control systems will be used by aircraft and airport vehicles during low-visibility conditions. In addition, drivers' enhanced vision systems will allow better aircraft rescue and firefighting and other airport vehicle operations in low-visibility conditions. The enhanced vision systems will include forward-looking infrared cameras and monitors in vehicles.

28.1.3 Airport Security

Security at major airports is provided through interrelated security measures and resources involving the FAA, airport operators, air carriers, and passengers.

The FAA is responsible for identifying and analyzing threats to security, prescribing security requirements, coordinating security operations, enforcing regulations, and directing law enforcement activities under the governing statutes and regulations.

Airport operators are responsible for providing a secure operating environment for the air carriers and other airport users by ensuring that responsive security programs and emergency action plans are maintained, air operations areas (AOAs) are restricted and protected, law enforcement support is provided to respond to various security threats, and physical security measures for the airport are provided.

Air carriers are responsible for screening passengers with metal detectors, as well as x-raying and inspecting their carry-on articles, securing baggage and cargo areas, protecting the aircraft, and maintaining responsive security programs. Air carriers generally use contractors to perform these functions but are held accountable by the FAA for the effectiveness of the screening operation.

Federal regulations set forth specific requirements for airport security programs, physical security and access control, and law enforcement support. Access control is required for perimeter, terminal, and ramp security areas. Airport perimeter access control usually includes signs announcing restricted areas, a fence barrier around key security areas, fence and perimeter alarm sensors, and lighting of important areas.

Terminal buildings present special security problems because of the proximity of public areas to the AOA. The security plan must allow access for authorized personnel while excluding unauthorized individuals from the AOA. Access controls from the terminal concourse to the AOA must be consistent with fire code provisions regarding exits from areas of public assembly.

The state of the art in airport security is expected to improve over time through accumulated experience and the application of new technology. Changes in security practices and requirements must be thoroughly coordinated with all affected parties, particularly airport operators, because of their potential impact on the cost and efficiency of airport facilities.

28.1.4 Airports Without Air Traffic Control Towers

The United States has 5,200 public-use airports—only 419 of them have airport traffic control towers (ATCTs). Air traffic controllers in the tower provide separation between aircraft and vehicles on the surface and between aircraft in the traffic pattern. At airports without towers, the separation is conducted by the pilots themselves. However, the architecture does include significant improvements, such as the Wide Area Augmentation System (WAAS) for improved navigation and instrument approaches, to assist pilots who use these airports. Towers will be built at new airports and airports experiencing significant growth that meet establishment criteria contained in Aviation Planning Standard Number 1.

28.1.5 Airports Without Radar Surveillance

Many airports today are not covered by radar surveillance. At these airports, instrument flight rules (IFR) services rely on pilot position reports to ensure separation. This is known as a "one-in and one-out" procedure. An arriving aircraft must confirm landing before another aircraft can be cleared to take off or to start an approach under IFR. This reliance on procedural separation increases air traffic controller workload. Procedural separation is less efficient for the pilots than radar separation.

Use of the one-in and one-out procedure will increase with the introduction of instrument approaches to airports that currently do not have approaches. Many of these airports are below radar coverage. The extension of radar coverage is not anticipated in the NAS architecture. The real promise for improved separation services rests with automatic dependent surveillance broadcast (ADS-B) as a basis for automatic dependent surveillance (ADS). Aircraft equipped with ADS-B and cockpit display of traffic information (CDTI) could be cleared for approaches and departures based on either self-separation or by air traffic control facilities that receive ADS-B reports from a nearby ADS ground station. The degree to which the one-in/one-out procedure can be eliminated will depend upon aircraft equipage with ADS-B avionics and installation of ADS ground stations in areas where there is no radar surveillance. Additional details on ADS may be found in Section 16, Surveillance.

28.1.6 Satellite-Based Navigation

The Global Positioning System (GPS) and its Wide Area and Local Area Augmentation Systems (WAAS and LAAS) will provide navigation guidance for all phases of flight, including surface movement. For most airports, approaches will be based on WAAS. For those requiring the equivalent of Category (CAT) II and III approaches, LAAS will be used. LAAS will also be installed at locations where, because of mountainous terrain or high latitudes, WAAS coverage is inadequate. See Section 15, Navigation, Landing, and Lighting Systems, for a further description of the navigation architecture.

28.1.6.1 Instrument Approaches

The FAA intends to develop thousands of new GPS-based approaches, including approximately 200 approaches to heliports. These approaches are currently under development at a planned rate of 500 approaches per year. GPS-based approaches provide both course and vertical guidance. Instrument approaches with vertical guidance were expensive to provide in the past, requiring the installation of specialized, ground-based, electronic approach aids, typically an instrument landing system (ILS) or microwave landing system (MLS) for each runway end. They also required extensive amounts of unobstructed airspace.

The cost and difficulty of providing approaches with vertical guidance limited them to very busy runways, particularly those serving scheduled commercial airlines. This paradigm will shift to a concept wherein satellite-based instrument approaches will serve many runways, with approach minima being determined by such factors as terrain, obstructions, missed approach path, airport geometry, and airport and approach lighting.

For example, if a general aviation airport were seeking a new approach for a runway, a WAAS precision approach might be established to provide minima of 400 feet and 1-mile visibility. This would be adequate for most general aviation users and would not require as extensive approach lights, runway lighting upgrades, or other capital improvements as are associated with a CAT I ILS with minima of 200 feet and ½-mile visibility.

If that same runway had obstructions in the approach that could not be removed by the airport operator, the minima would be adjusted upward. GPS precision approach minima need not be equivalent to CAT I ILS minima, even though GPS with WAAS will support approaches to 200 feet and ½-mile visibility. An airport that already has a CAT I ILS would receive a GPS/WAAS approach to the same runway with the same minima that exist today. When the ILS is decommissioned, the approach capability would continue, only it would be satellite-based.

Approaches to less than 200 feet and ½-mile visibility will require local area augmentation from LAAS, which provides the accuracy, availability, and integrity necessary to support lower minima. One LAAS can accommodate all runways on the airport and is significantly simpler to install, operate, and maintain than the multiple ILSs that were needed for an equivalent capability.

GPS/LAAS is currently planned for 143 locations, ultimately replacing CAT II/III ILS systems, supporting runway upgrades from CAT I ILS to CAT II/III GPS, providing differential correction for airports where terrain or limited WAAS coverage affects performance, and augmenting ADS-B surface surveillance. Additional locations may benefit from LAAS, but airport development would be necessary to realize these opportunities.

Airport managers need to know which ground-based systems will be used to back up GPS during the transition period and thereafter. The FAA is considering a variety of options and intends to select preferred scenarios at the earliest possible date. That information will be shared as it becomes available with airport operators and state aviation agencies to help support their planning activities. The FAA will budget for transition costs related to the facilities, equipment, and services that it has provided historically.

28.1.6.2 Precision-Missed Approach Navigation

WAAS or LAAS can also provide precision-missed approach navigation, resulting in lower approach minima for those airports that have difficult terrain or obstacle clearance situations. A precision-missed approach provides course and vertical guidance. Increased precision on missed approach is tied to a concept called required navigation performance, which would change the criteria by which procedures are to be developed. The FAA is evaluating changes in terminal procedure criteria to take advantage of satellite-based efficiencies in airspace use.

28.1.6.3 Precision Departures

This capability would replace or overlay current standard instrument departures. The advantage to the airport operator is increased precision on ground tracks and the possible benefits in managing airport noise.

28.1.6.4 Nonprecision Approaches

Less precise approaches are adequate to meet the needs of some users. Avionics cost will be lower, since the avionics will not require differential correction. At every runway end with a precision approach, there will also be a published, nonprecision approach with higher minima. This redundancy is important since the nonprecision approach acts to back up the precision approach.

28.1.7 Phasing Down Ground-Based Instrument Approach Aids

The FAA expects augmented GPS will eventually meet all instrument approach needs. However, an assessment of actual satellite-based navigation performance will be made after the fielding of WAAS and certification of approach procedures. Therefore, the FAA intends to phase down ground-based navigational and approach aids (Navaids) as discussed in Section 15, Navigation, Landing, and Lighting Systems.

Decisions on the decommissioning of any ground-based Navaids will take into consideration the availability of a replacement satellite-based navigation procedure, and there will be an overlapping period of coverage at each location to allow for avionics equipage. Phase-down of airport Navaids (excluding visual aids) is expected to begin as soon as practical. The FAA intends to recover and reassign the associated radio frequency spectrum.

The FAA is initiating a study to determine how many Navaids should remain in service to provide a redundant navigational capability. The participation of airport operators and users in the study is planned. The following key service issues are to be studied:

- Developing a phase-down schedule of Navaids beginning in 2005 matched to user equipage with GPS-compatible avionics
- Identifying sufficient ground-based Navaids to support IFR navigation throughout the transition to satellite-based navigation
- Identifying which Navaids will be required to support IFR operations at key airports for general aviation, scheduled air carrier, and

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commuter service operations, and along principal air routes following the transition to satellite-based navigation.

28.1.8 Surface Surveillance

Today, airport surface surveillance is provided visually by pilots, controllers, and vehicle operators. At larger airports, visual surveillance is augmented by airport surface detection equipment (ASDE-3). Due to the high cost, equipping additional airports with the ASDE-3 radar would not be feasible; however, a new program for a lower cost surface movement detection system paired with a conflict prediction capability has been approved and potential applications are being evaluated.

The airport movement area safety system (AMASS), which tracks targets, applies safety logic, and alerts tower controllers to potential surface movement conflicts, is being deployed to ASDE-3-equipped airports. This AMASS function has also been demonstrated using ADS-B. Section 16, Surveillance, contains additional details about the surveillance architecture.

28.1.8.1 ADS-B

ADS-B avionics broadcast aircraft position, speed (as derived from GPS), and other useful information (e.g., altitude, intent, aircraft identification) at regular intervals to other aircraft and ground stations. Depending on developments in the Safe Flight 21 Program, use of ADS-B for air-to-air surveillance (i.e., cockpit situational awareness) will begin in Phase 2 of the architecture. Use of ADS as a basis for airport surface surveillance is slated to begin around 2006; its use as a means of surface surveillance has been demonstrated by the FAA and the National Aeronautics and Space Administration (NASA).

Ground vehicles can be equipped with ADS-B for surface surveillance and vehicle management. Benefits such as more efficient aircraft servicing, snow removal, and airport maintenance will encourage airports to equip vehicles. As long as the message broadcasts from the vehicle and aircraft are compatible, ATC and airport surveillance capabilities can be merged.

Ground vehicle equipage costs are likely to be lower than the costs for aircraft equipage. Likewise, cheaper communications links would be possible for systems used to track ground vehicles only. Some vehicles would need to transmit position only, while others, such as operations and firefighting vehicles, would need to have targets displayed to the vehicle operator.

28.1.8.2 Cockpit Moving Maps

By combining GPS aircraft position data with an electronic map of the airport, the pilot can see the aircraft's location on a cockpit display. Adding ADS-B position reports from other aircraft and vehicles to that same display will present a complete surface traffic depiction, which could facilitate operations in limited visibility. Both NASA and the FAA have demonstrated the capability to transmit ATC traffic information via data link to cockpit displays. The advantages to airports might include reduced need for pavement fillets based on more accurate surface navigation by large aircraft and reduced reliance on lighting and signage in extremely low-visibility operations.

28.1.9 Information Sharing and Collaboration

To improve capacity and reduce delay, the architecture provides for information sharing and collaboration between users and service providers. Airports will be able to receive information through the services described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing. This includes the flight objects, which contain the status of all aircraft flying into and from the airport. This information can be used for flight information systems within the airport terminal and for scheduling maintenance and snow removal operations. Airport systems will be able to communicate with FAA systems through appropriate information security protocols.

28.1.10 Coordination of Plans

It is essential to coordinate the NAS architecture with airport operators and state aviation agencies in order to achieve the potential airport-related benefits. The NAS architecture provides information about changes in how and when services will be provided. Locally prepared airport master and layout plans provide details about future activity at specific airports and the development that will be needed to accommodate it. Together, these documents will assist in planning capital investments, addressing future noise and emissions strategies, and identifying opportunities to provide additional services to airport users

28.2 Airport Development

Airport development—especially construction of new runways, runway extensions, and major terminal expansions—can affect the local FAA workforce, facilities and equipment (F&E) funding, and operations appropriations. Typical impacts include the need for new Navaids; construction of new towers and their necessary equipment; and relocation of existing Navaids, underground communications and power cables, radar units, weather sensors, and other miscellaneous equipment. Depending on the circumstances, the cost of this work may be shared between FAA and airport operators, with some costs paid for by airport operators through reimbursable agreements.

Changes in the NAS can result in new requirements for airport development. For example, establishing a WAAS instrument approach for a runway that does not already have an approach for comparable minimum weather conditions may generate projects to upgrade runway marking and lighting and remove obstructions. Very large investments may be needed to acquire land, relocate parallel taxiways, and otherwise bring airfields up to the standards for low-visibility operations. Airport operators will need to decide whether or not to accept the approaches.

Needed airport development that is significant to national transportation is included in the National Plan of Integrated Airport Systems (NPIAS), a biennial report to Congress by the Secretary of Transportation. Airfield capacity is the largest development category in NPIAS, accounting for 23 percent of development costs. The NPIAS contains 3,294 existing airports, but development is concentrated at the busiest airports, with 44 percent at the 29 large hub airports that each accounts for at least 1 percent of the nation's total passenger enplanements. The airfield capacity development included in the NPIAS will help alleviate congestion at many busy airports. However, certain large metropolitan areas, such as New York, will still have severe problems, and the FAA will continue to focus on the need for additional capacity at those locations.

FAA initiatives to enhance capacity are described in the Aviation Capacity Enhancement Plan. Published annually, the Aviation Capacity Enhancement Plan focuses on the top 100 airports by enplanements. It addresses the application of new procedures, technology, and airspace development to supplement and enhance airfield construction.

28.3 Airport Funding

Airport capital improvements are funded from a variety of sources. Through the F&E program, the FAA pays for most navigation and approach aids and air traffic control facilities. Other airport improvements on the airfield and in the terminal area are undertaken and financed by the airport operator, usually a state or local agency. Local funds, particularly from airport revenues and the issuance of bonds that are backed by future airport revenues, are supplemented by the Airport Improvement Program (AIP) and Passenger Facility Charge (PFC) Program.

The AIP is a federal grant-in-aid program that accounts for about 25 percent of airport capital investments. The 3,294 airports in the NPIAS are eligible to receive AIP funds, and more than 1,000 grants are issued annually.

The AIP is distributed largely in accordance with FAA priorities, and the program focuses on airfield improvements, especially those that are safety-related. The AIP is particularly important to thousands of lower-activity airports that use all of their revenues for operations and maintenance and have little ability to undertake development without financial assistance. There may be a significant future requirement for AIP grants to assist improvements—such as paving, lighting, grading, land acquisition, and obstruction removal—needed by airports to obtain additional instrument approach capability and other potential benefits of the improved NAS.

The PFC is a locally imposed charge by air carriers for each enplaned passenger. PFCs account for about $1 billion annually and are particularly important at busy airports where there are large numbers of enplanements. The FAA must authorize PFC collection and use, but the eligible uses are broad, and the use reflects the airport operator's priority. There is a tendency to use PFCs to improve passenger movement areas, such as terminal buildings and ground access systems.

28.4 Summary

The airport is a key component of the NAS. Airport operators are involved in many aspects of system performance, including safety, capacity, and environmental capability. The FAA will continue to work with airport operators to maximize the effectiveness of NAS modernization initiatives.

28.5 Watch Items

- AIP funding level and stability in funding. The AIP program helps large and small airports expand to meet aviation needs. At the current rate of aviation growth, new runways will be needed. New airports at major urban locations may also be needed between now and 2015.
- Airport development and FAA capital development need to be closely linked so that airport operators and local FAA offices can plan delivery of new capabilities more effectively.

29 FACILITIES AND ASSOCIATED SYSTEMS

This section discusses three major FAA concerns: (1) maintaining existing facilities, (2) replacing and expanding facilities, and (3) new facilities. Also discussed are human factors, risk-mitigation activities, physical security, and costs related to these concerns.

"Facilities" are defined as driveways, roads, grounds, and staffed or unstaffed buildings that are owned, leased, or maintained by the FAA. The term "building" applies to an individual structure and to any enclosed, attached supporting utility systems such as electrical power conditioning and distribution systems and heating, ventilation, and air conditioning (HVAC) equipment.

Facilities must meet requirements mandated by public law and Executive order for facility accessibility and structural and nonstructural seismic reinforcement of occupied federal buildings. Newly constructed facilities and retrofits for existing structures are designed to meet these requirements. Security risk-reduction measures such as fences, guardhouses, and access control systems—when determined to be necessary—are considered as part of a separate security risk-management system for the building or facility. Additional requirements exist to upgrade the facilities to accommodate security risk-management measures. Physical security costs are covered in Section 31, Mission Support.

The FAA maintains and improves buildings and structures that house NAS equipment and personnel (see Table 29-1). Several key facilities are near the end of their forecasted structural economic life.

Refurbishing or replacing these facilities will sustain their existing capability. In cases where facilities are leased, landlords are responsible for some maintenance. However, the FAA maintains these facilities to the extent agreed upon in the leasing agreement.

Table 29-1. Average Age of Key NAS Facilities

Facility Type	Number	Average Age (Years)
ATCT (Towers)	419	26
ARTCC (Centers)	20	40
TRACONs (Terminals)	171	22

Based on their average age, most air traffic control (ATC) facilities will need to be substantially refurbished or replaced between 2001 and 2015. The NAS architecture accounts for this needed effort, and specific details will be developed over the next few years.

The requirements for facility upgrades caused by adding or modifying installed equipment will be defined by the acquisition program providing the new equipment or modification. These requirements include space, quality and quantity of power, and HVAC. A concurrent determination by the responsible line of business (LOB) and the acquisition program will be made concerning the impact of equipment addition or modification on the need for additional security risk-reduction measures at the facility.

29.1 Air Route Traffic Control Centers

The air route traffic control centers (ARTCCs) and the national network control centers (NNCCs) will get structural repairs, external repairs, and internal remodeling. Old water and sewer lines will be replaced. New or refurbished backup power equipment, power conditioning equipment, and batteries will be provided.

In addition, the FAA will make child care facilities available to employees at each of its ARTCCs. These facilities will be completed within the next few years.

29.2 Terminal Facilities

NAS terminal facilities include airport traffic control tower (ATCT) and terminal radar approach control (TRACON) installations. TRACONs include a category of large TRACONs, which consolidate the terminal control responsibilities formerly managed by two or more TRACON facilities. A current example is the proposed Potomac TRACON that will control airspace presently under the jurisdiction of Dulles, Baltimore-Washington, and Ronald Reagan Washington National Airports, along with Andrews Air Force Base—all located in the Washington, D.C., metropolitan area.

Table 29-2. New TRACON Consolidations

Large TRACON	Consolidated TRACONs
Denver	Colorado Springs Pueblo Grand Junction
Atlanta	Atlanta Macon Columbus
Potomac	Dulles National Baltimore Andrews AFB
Northern California	Oakland Sacramento Stockton Monterey Selected Oakland Center Sectors
Central Florida	Jacksonville Orlando Tampa Patrick AFB

Source: NAS Transition and Integration, Terminal Facilities Division (ANS-200)

29.2.1 TRACON and Airport Traffic Control Tower Facilities

Standby power and HVAC equipment at all facilities will be replaced over the next 20 years. Site security systems will be upgraded, with special attention given to the physical security at supporting facilities located on remote islands.

Annually, selected ATCT installations and TRACONs are modernized to accommodate additional traffic at airports and to extend their service life. TRACONs/towers are replaced or consolidated with other operations if they have reached the end of their economic life.

Airport cable loop systems are being upgraded or replaced with fiber optic technology. This upgrade provides the facilities with state-of-the-art communications pathways and allows for redundant nodes and pathways for communications, should a cable cut occur.

Airport traffic control towers and TRACON facilities are evaluated for modernization or replacement in accordance with FAA Order 6480.17. Fifty-three facilities are qualified and validated for establishment or replacement, with 18 of these presently under construction and installation of electronics.

Over the next several years, the FAA will build six to eight replacement facilities per year. The Honolulu TRACON will be expanded to house the combined center radar approach control (CERAP) in Hawaii. A TRACON/tower facility will be completed for Austin-Bergstrom International Airport. Several other airports will qualify for federally funded contract ATC facilities.

29.2.2 Large TRACONS

The New York TRACON facility will be expanded or replaced. The five facilities shown in Table 29-2 will consolidate several existing ATC facilities into a single ATC facility. These facility consolidations will support a more efficient design of the airspace in selected U.S. geographic areas. Facility consolidation will improve ATC operations and reduce the total cost of operating multiple smaller facilities.

Airspace actions are subject to environmental assessments and procedures if the area of the proposed facility is less than 3,000 sq. ft. Compliance with the National Environmental Policy Act of 1969 (NEPA) is mandatory for each organization establishing an airspace configuration.

29.3 Flight Service Station Facilities

The installation of the Operational and Supportability Implementation System (OASIS) requires additional space, electrical power capacity, and HVAC at existing automated flight service station (AFSS) locations. In addition, power conditioning and battery backup capabilities will be added at those AFSSs that experience frequent interruptions due to power fluctuations.

29.4 General NAS Facilities

General NAS facilities—numbering well into the thousands—house and support communications, surveillance, and navigational aids. All of these facilities are aging and must be periodically refurbished. This ongoing need is handled by prioritizing the facilities on the basis of their condition, criticality of their function to the NAS mission, and other criteria. The top-priority facilities then receive roofs, paint, siding, or whatever is needed to complete refurbishment and bring the facility up to current standards. Additional requirements exist to upgrade the facilities to accommodate security risk-management measures.

29.5 NAS Support Facilities

Facilities and equipment at the William J. Hughes Technical Center (WJHTC) in Atlantic City, N.J., are failing and need refurbishment. Specifically, chiller and boiler units and electrical substations are scheduled to be refurbished or replaced. Drainage system and fire protection system improvements will be accomplished. Refurbishment of FAA-owned airport runways, taxiways, shoulders, and airport lighting systems is planned.

Plans include new facilities at the Mike Monroney Aeronautical Center (MMAC) to provide areas for training, logistics, engineering, and aeromedical research. New training complexes will provide classrooms, training laboratories, and work areas. New engineering support areas will accommodate support personnel, systems, equipment, and functions for defining and resolving NAS problems, sustaining engineering functions, and related activities. The logistics support area provides space for repair, test, quality control, engineering, and supply support functions. The Civil Aeromedical Institute, general Aeronautical Center operations (e.g., storage, staging, shipping, maintenance, flight line support), and other tenant needs will be accommodated.

29.6 FAA Residences (Employee Housing)

The FAA operates and maintains quarters for employees and their families in remote areas where suitable housing is unavailable. This ongoing effort provides, maintains, and refurbishes residences and other temporary quarters in Alaska, the Caribbean, the Grand Canyon, Nantucket, and the Pacific Territories. The FAA also leases housing units when it is economical.

29.7 Facility Power System Maintenance

Current power systems provide for various levels of reliability for the NAS system, service, or facility to be supported. The level of air traffic activity determines the design of the power system installed. The most critical facilities—ARTCCs and some large TRACONs—have multiple redundant systems, which include at least two separately derived utility power sources, multiple uninterruptable power systems, and excess engine/generator capacity to allow for engine/generator failure.

Newer technology systems have less tolerance for power interruptions than the older equipment. Most new systems, especially commercial-off-the-shelf-based workstations, require several minutes to reboot and reload software when power is interrupted. For some critical air traffic systems and services, this type of interruption is unacceptable. To prevent these occurrences, uninterruptable power systems are provided. The most expensive components are the batteries, which have a service life of 5 to 10 years.

Approximately 3,500 engine/generator units are available for standby power. Most of these engines are over 20 years old and are being replaced on a scheduled basis. The current goal is to maintain an engine/generator inventory that is no more than 15 years old.

Facility power systems, including power control cables and lightning protection, are also considered part of the infrastructure and are currently being upgraded.

29.8 Environmental Concerns

The FAA is subject to a number of environmental statutes and regulations when either establishing or disposing of facilities. These concerns are addressed in Section 30, Environment and Energy.

29.9 Facility Security

The FAA uses thousands of navigation and ATC facilities of all types, sizes, and functions to carry out its responsibilities for efficiently managing and controlling the NAS. Damage to or destruction of any FAA facility has a measurable affect on the NAS—depending on the criticality of the facility and its mission in overall NAS operations. Federal facilities may be vulnerable to potential internal sabotage and external attacks, which could disrupt NAS operations, degrade flying safety, compromise national security, and damage the U.S. economy.

All elements of the FAA's critical infrastructure need physical facility security protection. Critical assets at FAA facilities need to be identified, risks assessed, and the threats and vulnerabilities to those assets reduced or eliminated. Physical security must be addressed in an orderly, logical process that results in cost-effective risk reduction and minimizes operational inconveniences while preserving operational integrity.

As a federal agency, the FAA and its facilities are required to comply with those minimum facility physical security standards identified in the June 1985 Department of Justice (DOJ) report, *Vulnerability Assessment of Federal Facilities*. The FAA is currently conducting facility physical security surveys and assessments to identify critical security risks. These surveys will lead to risk-reduction measures that will ensure each facility meets baseline security standards identified in the DOJ report and FAA Order 1600.6c (FAA Physical Security Management Program).

Plans for new facilities or major modification to existing facilities will be coordinated with the Office of Civil Aviation Security Operations (ACO-400) to ensure appropriate security measures have been included in the design plans. Facilities that are to be occupied by FAA elements must have provisions that enable facility management to:

- Control access into the facility at all times
  - Reduce the number of entrances to the minimum consistent with the operational needs of the facility
  - Locate parking 100 feet from the facility and in one area on the facility site
- Control the removal of and/or the unauthorized access to FAA property, equipment, personnel, and official records
- Obtain protective services and/or public safety response when disorders or other emergency situations arise.

Utility systems vital to the continued operation of the NAS facility will be protected against tampering, vandalism, and sabotage. Where possible, areas containing critical utility systems will not be located adjacent to high-use areas, such as loading docks, visitor entrances, parking areas, etc. Where key utilities must be located outside the main structure, whenever possible they will not be located within 100 feet of the perimeter fence, boundary, or parking areas. Such utilities would include:

- Telephone and electrical closets
- Power supply equipment to include emergency power equipment
- Power conditioning equipment and rooms
- Environmental control systems
- Air conditioning rooms and equipment.

The design of a NAS facility should emphasize the internal and external configuration of the facility and the proper placement of assets or resources having security considerations. The correct location of a facility function can often serve as an effective safeguard and deterrent against unauthorized entry, theft, or sabotage.

Electronic card access systems, intrusion detection alarms, and closed-circuit television are increasingly used in FAA facilities. Close coordination with ACO-400 and the responsible civil aviation security regional office will ensure human resources, equipment hardware, and software are fully integrated for the protection of personnel, facilities, and assets. FAA regional civil aviation security offices will conduct security surveys of new or renovated existing facilities to determine and establish baseline security risk-reduction measures that will ensure that each facility meets the minimum federal physical security standards identified in FAA Order 1600.6c and the DOJ report.

29.10 Human Factors

Providing the proper facilities and environment for the people and equipment that support the NAS requires application of human factors engineering during the acquisition of FAA facilities (whether new, modified, or consolidated). This approach is similar to the way human performance considerations are incorporated into other FAA acquisitions for systems and services.

Human-workspace interfaces, human operational requirements, and associated safety considerations within the facilities are the basis for including human factors engineering during the planning (buy, lease, or build), alternative analysis, design, testing, and acceptance of facilities. Human factors engineering focuses on identifying and resolving human engineering and ergonomic issues related to operational requirements, workspace and equipment layout, team communication, organizational design, and personnel health, comfort, and occupational safety.

This approach reduces long-term costs (through efficient design and use of personnel resources, skills, training, and procedures for the facility),

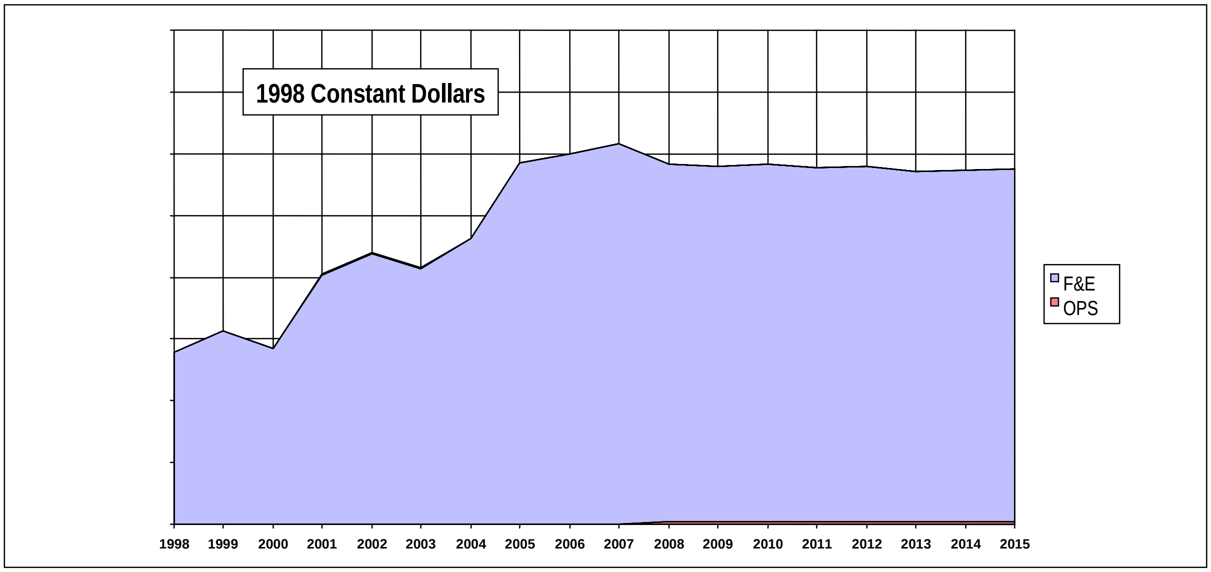

Figure 29-1. Estimated Facilities Costs

minimizes the need for facilities modification (through improved compatibility and suitability with the operational and maintenance concepts), and enhances the performance of NAS operations and maintenance.

29.11 Costs

The FAA estimates for facilities and equipment (F&E) and operations (OPS) life-cycle costs for facilities and associated equipment architecture from 1998 through 2015 are presented in Figure 29-1. OPS costs are for computer aided engineering graphics (CAEG) system maintenance.

29.12 Summary

The FAA must continue to maintain its facilities and associated systems. The key facilities in the NAS are aging and supportability of the facilities is a critical need that the FAA can no longer defer.

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30 ENVIRONMENT AND ENERGY

30.1 NAS Modernization Impact

NAS modernization will produce a series of expected environmental benefits, including fuel conservation, fewer FAA facilities, and more energy-efficient new facilities.

Air travel fuel conservation will reduce emissions of greenhouse gases and other pollutants. Estimates of reductions for the years through 2015 were developed for a projected fleet mix and projected traffic increases by phase of flight (e.g., en route) in the continental United States. Results indicate potential annual savings of over 10 billion pounds of fuel, over 200 million pounds of both nitrogen dioxide and carbon monoxide, and 60 million pounds of hydrocarbons, as compared to what would be used without NAS modernization.

The Global Positioning System (GPS) is expected to require fewer land-based navigation facilities. Thus, this land may be available for other uses, and less use of environmentally sensitive lands is expected. New facilities and equipment will generally be more energy-efficient, which will reduce FAA operating costs and emissions of greenhouse gases and other pollutants from these facilities.

Contaminated sites will be cleaned up during the decommissioning and disposal process. While some real property, equipment, and supplies may be preserved by the FAA or other organizations, much will be recycled or used for non-FAA purposes. With fewer land-based facilities, community controversy over aesthetics and electromagnetic fields may be avoided.

The NAS architecture demonstrates the FAA's leadership in meeting federal goals for sustainable development. Sustainable development is defined as "meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs."[1]

The United States committed itself to sustainable development at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro and in the 1996 President's Council on Sustainable Development report, *Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future.* One of the key principles of sustainable development is that a healthy economy depends on healthy communities and a healthy environment for all. Through the NAS architecture, the FAA will foster safety in aviation, in tandem with federal goals for national security, economic growth, environmental health, and community needs.

The FAA has developed and is implementing specific mandated programs in the areas of environmental compliance, occupational safety and health compliance, and energy conservation. These programs apply to acquisition of new equipment and facilities and disposal of existing equipment and facilities.

In the decisionmaking process for siting, operating, and disposing of new FAA facilities, the FAA is required to consider the effects of proposed actions on the human environment by the National Environmental Policy Act of 1969 (NEPA) and the Council on Environmental Quality (CEQ). The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences and take actions that protect, restore, and enhance the environment.

Although the primary consideration in modernizing the NAS is aviation safety, the NAS—to be acceptable to the public—must and will address other public concerns related to human health, welfare, and safety. These concerns about impacts on the human environment (both positive and negative) include noise changes, community disruption, relocation, surface and air traffic changes, changes to sensitive cultural and natural resources (e.g., preservation of wildlife refuges, National Parks, and bird sanctuaries), air and water quality, water and sewer demand, energy demand, aesthetics, site cleanup, and concerns about electromagnetic fields.

30.2 Environmental Compliance and Cleanup Program

The FAA recognizes the need to comply with all federal, state, and local environmental require-

1. *Our Common Future, 1987* (Brundtland Report), United Nations World Commission for Environment and Development, 1987.

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ments. The agency has moved forward with implementing the Hazardous Materials (HazMat) Management/Environmental Cleanup Program to systematically identify, evaluate, and remediate environmentally contaminated sites in the NAS (including site characterization, remediation plans/designs, cleanup activities, and monitoring). Programs include, but are not limited to, the fuel storage tanks, recycling and waste minimization, hazardous waste disposal, contamination assessment and cleanup, and polychlorinated biphenyl (PCB) programs.

30.3 Occupational Safety and Health Program

The mission of the Occupational Safety and Health (OS&H) program is to provide for the occupational safety and health of employees, prevent accidental loss of material resources, avoid facility interruptions due to accident or fire, and enforce a system of formal accountability. This is accomplished through regulatory compliance and program management principles. The program provides the comprehensive, agencywide occupational safety and health actions/activities (including fire life safety) necessary to ensure FAA compliance with federal mandates and negotiated agreements to integrate a philosophy regarding these areas of effort into the FAA culture and to promote a safe and healthful workplace.

This effort starts in the design phase of a system or project, thereby reducing the probability of retrofit or noncompliance, and continues throughout the entire life cycle. Significant parts of the programs are field-oriented and administered at the regional level. Some examples of mandated programs are the Lockout/Tagout, Fire Protection, Fire/Life Safety, Confined Space, Fall Protection, Hearing Conservation, Personnel Protective Equipment, Compressed Gas Safety, Hazard Communication, Training, Walking/Working Surfaces, and Housekeeping programs.

30.4 Energy Conservation

The Federal Energy Act and Executive Order 12902 require the FAA to reduce facility energy consumption to 1985 levels. Recent federal legislation also requires all federal agencies to use life-cycle costing analysis when procuring new systems in order to enhance the transition of new and efficient technologies into the workplace. The FAA program will integrate “best available technologies” into acquisitions to improve system operability while reducing energy consumption. By monitoring utility resource expenditure savings, the FAA will be able to retain and reinvest the savings in the energy program’s future.

30.5 Property Transfer Environmental Liability

As in the private sector, federal agencies may be held liable for cleanup of site contamination as an owner or operator of a site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). As a result, evaluating candidate properties for potential environmental contamination and liability has become one of the essential steps in real property transactions. Known in the FAA as the Environmental Due Diligence Audit (EDDA), this evaluation process applies whether acquiring, leasing, transferring, or terminating agency interest in real property. As the NAS architecture is realized, real property transactions—terminations or disposals of property in particular—will increase. To avoid long-term liability and ensure compliance with CERCLA and the Community Environmental Response Facilitation Act (CERFA), the FAA must conduct EDDAs, document hazardous waste activities, and clean up any contamination on real property transferred out of the Federal Government.

30.6 Research, Engineering, and Development

Protecting the environment poses the greatest single challenge to continued growth and prosperity of the aviation system. The FAA is committed to environmental stewardship of all programs, systems, and facilities in order to identify and correct environmental problems before they pose a threat to public welfare, employees, or the quality of the environment. Through an optimal mix of aircraft and engine certification standards, operational procedures, compatible land use, and abatement technology, the agency intends to reduce the impact of aircraft noise.

This will also minimize the impact of aircraft emissions and assist airports in applying practicable measures to avoid or minimize adverse impacts on air, soil, and water quality. The FAA’s Plan for Research, Engineering and Development details the programs selected to ensure continued safety, security, capacity, efficiency, and an environmentally sound aviation system. The R,E&D Plan should be consulted for detailed information in this area.

The FAA and the National Aeronautics and Space Administration (NASA) have been working together on this issue. In 1995, the FAA and NASA administrators signed a memorandum of understanding (MOU) on airspace system users operational flexibility and productivity.

The MOU establishes an FAA/NASA interagency air traffic management integration product team (IAIPT) responsible for planning, oversight, and management of joint efforts. The principal defining documents for the IAIPT are the *Integrated Plan for ATM Research and Technology Development* and the IAIPT management plan.

30.7 Costs

The FAA's estimates for research, engineering, and development (R,E&D) and facilities and equipment (F&E) for environment and energy life-cycle costs associated with regulatory compliance for 1998 through 2015 are shown in constant FY98 dollars in Figure 30-1. Estimates for operations (OPS) costs are included in Section 31, Mission Support.

30.8 Summary

Modernizing the NAS will have predictable and unpredictable impacts on the environment. Many of the modernization efforts will have the benefit of reducing pollution and gaseous emissions. Replacing the aging NAS infrastructure, however, poses numerous problems in terms of avoiding surface pollution, as well as unknown costs for rehabilitating contaminated sites scheduled for decommissioning or replacement.

The Federal Energy Policy Act and Executive Order 12902 require the FAA to meet certain energy and water conservation goals. The goals are to reduce cost, improve the environment, and minimize the use of petroleum-based fuels in FAA buildings and facilities. The FAA is required, among other things, to reduce energy consumption in FY00 by 20 percent from FY85 levels and in FY05 by 30 percent from FY85 levels.

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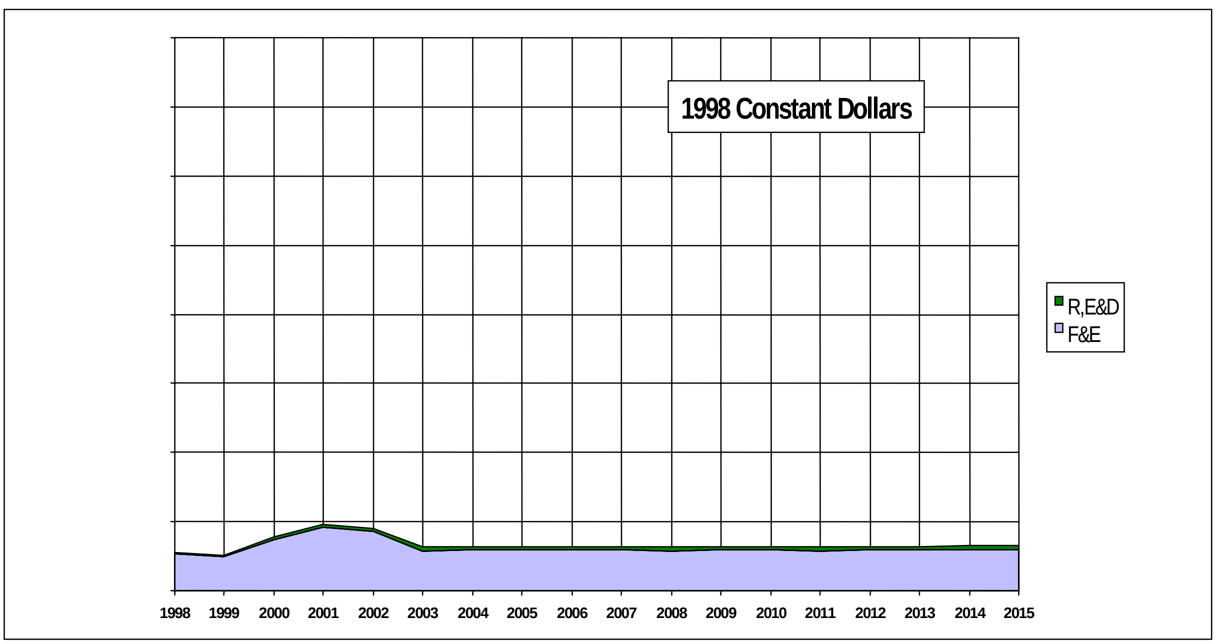

Figure 30-1. Estimated Environment and Energy Costs

31 MISSION SUPPORT

Mission support services assist the agency in delivering primary services and meeting strategic and performance goals cited in the *FAA Strategic Plan.*

For this discussion, mission support services are grouped into three categories: strategic support functions, tactical support functions, and business operations. Strategic support functions support the agency over the long term, whereas tactical support functions are involved with day-to-day agency operations.

Three major assumptions have been made for purposes of this discussion. First, specific hardware, software, or other items needed by a support function (e.g., Logistics Center spare parts) to implement a particular program will be identified, approved, and funded as part of that program through the investment analysis process. Second, all FAA personnel costs to perform the functions identified in this section have been captured in Section 12 and Sections 14 through 27. Third, the final disposition of a support system used in NAS modernization (e.g., one used for testing or training) will be decided during the investment analysis process.

31.1 Strategic Support Functions

Strategic support functions are performed by one or more FAA organizations to support air traffic management or regulation and certification services over the long term.

NAS Integrated Performance Management

The Air Traffic Services (ATS) NAS integrated performance management function develops customer-oriented outcome-based system performance measures and monitors system performance. It also recommends strategies for performance improvement. Performance measures represent operational outcomes desired by NAS users. The outcomes reflect overall performance across all air traffic management services.

Performance measures are developed in conjunction with the user community. Systems initially supporting this function include the Air Traffic Operational Management System (ATOMS), National Airspace Information Monitoring System (NAIMS), the Consolidated Operations and Delay Analysis System (CODAS), and the National Airspace System Performance Analysis System (NASPAS).

Airspace Management

The FAA has custodial management responsibility for airspace. The existing airspace structure was designed around the concept that airspace can be partitioned into volumes that air traffic controllers could monitor and use to maintain separation of aircraft. Increased traffic and changing customer needs have required changes in operations and air traffic management and have highlighted the need for airspace management to evolve and focus on a national perspective. The strategic airspace management function identifies the requirements and plans for airspace changes and also supports their implementation. A key system supporting this function is the airspace analytical tool system (AATS). The system analyzes NAS airspace safety, efficiency, capacity, design, and billing (i.e., user fees). It also assesses environmental issues associated with airspace changes.

Aeronautical Information Service

The Aeronautical Information Service collects, validates, and disseminates aeronautical information. The service provides an up-to-date repository of information about NAS elements (e.g., airports/runways, Navaids, fixes, remote communication outlets, and towers). The aeronautical information is used for publishing charts and documents and as electronic NAS configuration data for airspace analysis, flight service, weather, and other electronic systems. The future architecture of the Aeronautical Information Service is designed for source data entry and online access to current information. The Operational Data Management System (ODMS) is replacing the current closed system architecture.

Air Traffic Operations and Procedures

The FAA needs the capability to monitor and manage its air traffic operations on a continuing basis. It also needs to plan for meeting the demand of current and future forecasted air traffic services. The strategic operations and procedures function supports these activities. This function develops and maintains the FAA's NAS Concept

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of Operations document used to guide NAS architecture development; assists with requirements validation and with implementing new systems into the NAS; and develops and publishes new air traffic procedures required to support NAS modernization.

NAS Transition, Integration, and Implementation

This function supports the capability to implement and integrate new systems and facilities into the NAS. Types of activities include site selection analysis, site preparation and construction, equipment installation and testing, facility transition plans, system inservice reviews, and other activities. It develops guidelines and policies for transition planning of NAS programs and identifies and coordinates resolution of implementation and transition issues among NAS programs.

This function includes computer-aided engineering and 3-dimensional design tools for facility modeling and site analyses that support transition, installation, and site planning.

System Maintenance Operations

This function provides guidance and tools to monitor NAS systems and manage the operation and maintenance of the systems. It also provides for the planning and management of leased communications.

System Support Operations

This function provides second-level hardware and software engineering support to the NAS field facilities. The function includes documentation control, publication and issuance of directives, and inservice improvements. Strategic operational support activities include planning for second-level engineering support, managing the NAS software life cycle, developing second-level national software engineering policy, providing software support tools and practices, and providing configuration management of inservice hardware and software.

NAS Spectrum Engineering Management

By national policy, the FAA is the manager of all aeronautical spectrum required to support NAS communications, navigation, and surveillance (CNS) systems. This spectrum must be available at all times and be free of radio frequency interference. This function provides support to obtain and protect necessary frequencies for current and future NAS operations. Additionally, the FAA provides both national and international coordination for aeronautical mobile services, aeronautical fixed services, and aeronautical mobile satellite services in developing International Civil Aviation Organization (ICAO) standards and recommended practices.

This function provides spectrum engineering and frequency management support for NAS modernization projects. Furthermore, the function provides the regions with the training, resources, and equipment (i.e., spectrum analyzers and handheld direction finders) required to independently identify the source of interference in a timely manner.

System Requirements, Design, and Acquisition

This function identifies and prioritizes mission needs; baselines system cost, performance, and user benefits; documents requirements; recommends alternative solutions; and supports implementation of selected alternatives. The function provides automated tools, facilities, and processes for research, engineering, and development (R,E&D) management and implementation, mission and investment analysis, system engineering and analysis, software engineering analysis, system development and testing support, program engineering and evaluation, acquisition support, system implementation, and deployment decisions.

This function develops and maintains the NAS architecture. It manages crosscutting NAS information technology programs, such as NAS information standards activities and NAS information security activities. Costs for these activities are covered in Sections 19 and 9 respectively. It also provides R,E&D management, NAS program management, mission and investment analysis, and system engineering.

Operational Testing and Aviation Research

The William J. Hughes Technical Center (WJHTC) provides technical laboratories to support NAS testing and aviation research activities. This function coordinates space requirements, installation plans, and changes to ensure the laboratory meets testing and research needs. Other technical laboratories are used by the FAA, and the costs for these laboratories are captured under each individual application.

This function provides unique nonoperational test beds, not available elsewhere, that duplicate the NAS environment. This function also provides support applications, fixed-wing aircraft and helicopters to provide flight data for projects, ATC simulation support, data centers for computational modeling and research data analysis, and human factors support.

Logistics Support

The logistics function is responsible for depot and limited field maintenance; supply support for NAS equipment and agency aircraft; replenishing and repairing spares; and purchasing, leasing, and managing real estate, including land, office space, and specialized facilities. This function identifies the requirements for and funds the acquisition of spare parts and repair services and other logistics-related activities, such as contracted logistics support and logistics training.

Training

The training function, as defined here, supports general FAA training requirements, including those for NAS modernization activities and operations. The FAA Academy at the Mike Monroney Aeronautical Center (MMAC) conducts technical training and maintains high performance standards for air traffic controllers, engineers, inspectors, and other FAA specialists. A portion of the academy is dedicated to training international aviation personnel through the International Training Services Center (ITSC), which promotes seamless transitions by introducing the new technologies being incorporated into the NAS.

Academy classrooms, laboratories, and instructional staff work areas need to be modernized to fulfill the FAA training mission to coincide with new technologies entering the NAS. The training function identifies requirements for and provides the tools and internal infrastructure to deliver technical training courses. This function includes funding for the FAA Academy, contracted training, and computer-based instruction equipment replacement, upgrades, and conversions to reduce overall training costs.

The Center for Management Development supports the agency's continuing efforts to ensure a safer, more efficiently managed NAS. The center's curriculum is broad and designed to strengthen both interpersonal and technical management skills. All courses focus on actual job functions to help build the specific skills needed to improve job performance.

Flight Inspection and Procedures

Flight inspection and procedures functions are performed by Aviation System Standards (AVN) at the MMAC, FAA Headquarters, the Air Traffic Control System Command Center (ATCSCC), and in the regions. The National Flight Procedures Office, located at the MMAC, is the central location for the development and standardization of instrument flight procedures and related technical support functions. The Flight Inspection Operations Division performs flight inspection functions and provides the tools and infrastructure to support in-flight inspection and evaluation of air navigation aids and instrument flight procedures. The FAA's flight inspection aircraft support domestic, foreign, and military worldwide navigational air inspection requirements.

This function procures and leases FAA flight inspection aircraft and provides FAA Academy flight simulators used to train aviation safety inspectors. The function also develops automated systems, including the instrument approach procedures automation (IAPA) system and the aviation standards information system (ASIS). The IAPA system provides automated tools to assist development of timely and accurate standard instrument approach procedures (SIAP).

Regulatory and Certification Activities

This function includes regulatory and certification activities not covered elsewhere. It provides the tools and processes needed to support ATS and other organizations in performing regulatory- and certification-related activities. A key system supporting this function is the obstruction evaluation/ airspace and airport analysis (OE/AAA) system.

31.2 Tactical Support Functions

These functions are performed by one or more FAA organizations to support air traffic management and regulation and certification services.

Air Traffic Operations and Procedures

The tactical operations and procedures support function monitors day-to-day NAS operations. It also includes such activities as contingency planning and facility evacuation.

Flight Advisory and Hazardous Information Service

This service provides real-time information affecting flight conditions to pilots by issuing notices to airmen (NOTAMs). NOTAMs are collected, processed, and distributed via the weather message switching center replacement (WMSCR), the Consolidated NOTAM System, the National Airspace Data Interchange Network (NADIN), and other means. The Consolidated NOTAM System will be replaced by ODMS.

System Maintenance and Operations Support

System maintenance and operations (SMO) support provides onsite maintenance and repair services throughout the NAS. These services include site program implementation of new facilities and equipment; first-level technical engineering support for the NAS hardware and software; certification and verification of operational hardware and software; day-to-day technical assistance and coordination for hardware and software users; and certification of services provided to the air traffic environment, automation, communications, and surveillance.

System Support Operations

Tactical support includes developing hardware and software modifications, implementing approved changes, evaluating systems and system changes, and other tasks as required to ensure reliability and maintainability of the NAS. Operational support activities include maintaining operational software for all NAS systems; providing second-level hardware and software engineering support to field facilities; developing and implementing hardware and software enhancements; participating in systems operational test and evaluation and verification; and conducting system shakedown tests.

Logistics Support

This support function provides procurement, real estate, material management, and automated data processing support services to implement capital investment programs in the regions and centers. This function uses contracted support for many of its activities.

Training

The tactical training function provides on-the-job training for controllers and other specialists. This function supports technical training conducted or contracted out at regional or local facilities.

31.3 Business Operations

Business operations functions support the delivery of all FAA services. The following paragraphs provide high-level descriptions of several business operations functions.

Management and Planning

This function includes activities such as conducting special studies, evaluations, and appraisals; developing staffing standards; disseminating information and policy; and supporting the agency in organizational analysis, management studies, and management productivity. It implements the National Performance Review (NPR) Customer Service Initiative, supports strategic and business performance planning efforts, and develops the Government Performance and Results Act (GPRA) Annual Performance Plan.

Safety Data Analysis and Reporting

FAA management needs timely, accurate, and comprehensive information to support safety decisionmaking. The safety data analysis function provides the tools to identify previously hidden indicators of potential safety problems. The NAS Data Analysis Center (NASDAC) facility has been established at FAA Headquarters to support this function. Online services will be provided for FAA personnel and for the public.

Human Resources Management

This function develops plans and programs relating to recruitment; employment; compensation; benefits; performance management; training; human resource planning, evaluation, and development; and labor and employee relations. The function supports all training activities not addressed elsewhere.

Financial Resources Management

The financial resources management function develops plans and programs for accounting, budget, and financial management, including financial management systems. It prepares financial management reports, performs accounting operations, prepares and justifies budgets, sets travel policy, collects user fees, and supports financial reform initiatives. The function, under the guidance of the Chief Financial Officer, implements the agency's Internal Control Review Program and the Federal Integrity Act Program. It also designs and implements the new cost accounting system to study the possible implementation of user fees and meet other new requirements.

Information Resources Management (IRM)

This function plans for and develops corporate information systems and maintains corporate information technology management policy. All FAA organizations participate in this function. It manages crosscutting information technology activities and major information technology service contracts such as the integrated computer environment-mainframe and networking (ICE-MAN). This function also implements the Information Technology Management and Reform Act of 1996 (ITMRA). Major IRM/IT activities include the following:

- *Year 2000 (Y2K) Computer Program.* This activity provides for the renovation of all FAA systems that are currently not Y2K-compliant. Many FAA systems, including its core business systems as well as those that comprise the NAS, have been identified as mission-critical and will be affected by the Y2K problem. All FAA systems must be Y2K-compliant before the arrival of the millennium to ensure continuation of safe, efficient, and reliable air traffic services. FAA systems are undergoing a five-phase Y2K repair process, consisting of awareness, assessment, renovation, validation, and implementation. Through this process, all FAA systems will be certified as Y2K-compliant and implemented by June 30, 1999.

- *Corporate Systems Architecture.* This activity establishes, maintains, and enhances an agencywide systems architecture. It concentrates on three distinct elements: software engineering; technology and architecture; and data management, access, and information technology security.

  – The software engineering element focuses on improving the maturity level of FAA organizations and major system suppliers, developing an information architecture for the current Host system to support Host replacement activities, providing guidelines for using commercial off-the-shelf (COTS/nondevelopmental items (NDI) in ground-based systems, and developing guidelines and procedural changes necessary to streamline the software aspects of certification for avionics and ground-based systems. Also, the FAA will help RTCA Special Committee 190 elaborate guidance on use of DO 178B for ground-based systems and using COTS components. This activity will be supported by multiyear FAA programs to increase knowledge of how to certify COTS software components to DO 178B.

  – The technology and architecture element develops standards and implements an interoperable infrastructure to guide government, industry, and the FAA in purchasing, developing, and certifying software-intensive systems. It will permit applications to run on a variety of hardware platforms and minimize the cost of incorporating new standards in software and hardware.

  – The data management element supports establishment of secure electronic data interchange to ensure access to information, people, and organizations needed for decisionmaking.

- *NAS Management Automation Program (NASMAP).* This activity provides the infrastructure, architecture, and operational capability to structure and provide access to mission-critical data for those employees, managers, and executives who need the data for work or decision processes.

Acquisition Management

This function develops and maintains acquisition policy and guidance and implements acquisition reform. It provides contracting and procurement support for agency acquisitions.

Administrative Facilities Management

This function performs activities such as building space management, administrative telecommunications management, property management, utilities management, and other administrative management functions.

31.4 Costs

FAA estimates for R,E&D; operations (OPS); and facilities and equipment (F&E) costs for mission support and regulation and certification services are depicted in constant FY98 dollars in Figure 31-1. It is assumed that leases and projects requiring annual funding will continue indefinitely. Contracts that provide services or technical expertise will be funded as required, and these costs will increase as the level of modernization, defined in the NAS architecture, requires additional R,E&D, acquisition, system engineering, implementation, and regional support. Technology refresh costs are included for information technology systems, and OPS costs are included for fielded information technology systems.

31.5 Summary

The FAA is striving to maintain its capability to provide the best ATC services to its customers. Mission support services enable the agency to meet strategic and performance goals.

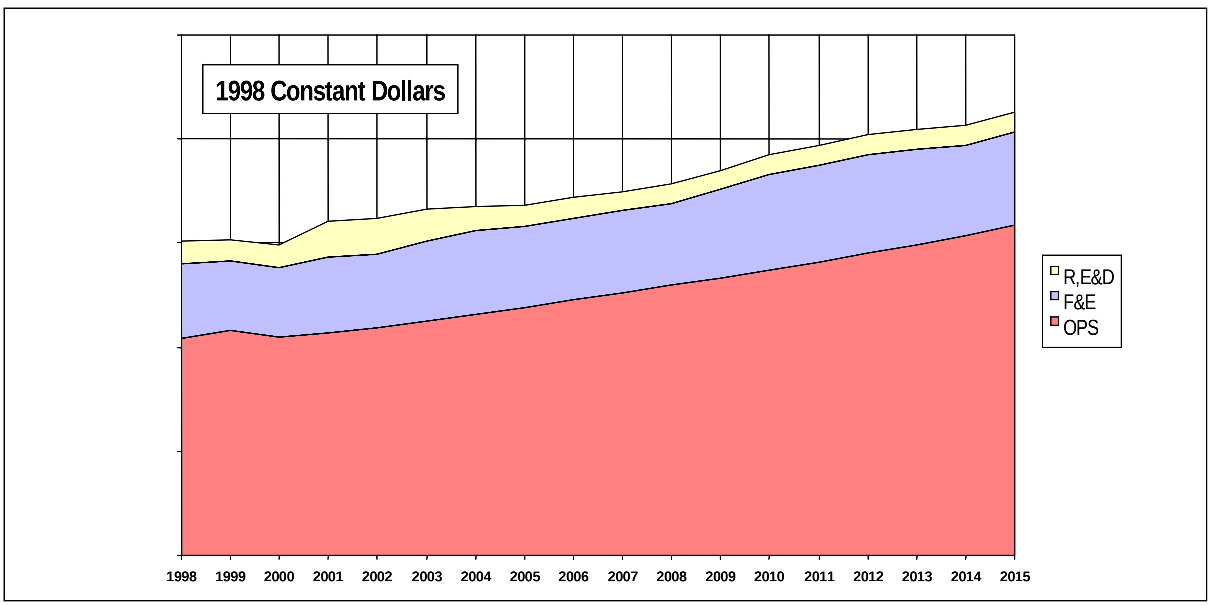

Figure 31-1. Estimated Mission Support Costs